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<b>(21) International Application Number:</b> PCT/US98/11932 <b>(22) International Filing Date:</b> 10 June 1998 (10.06.98) <b>(30) Priority Data:</b> 60/052,991 11 June 1997 (11.06.97) US <b>(71) Applicant (for all designated States except US):</b> HUMAN GENOME SCIENCES, INC. [US/US]; 9410 Key West Avenue, Rockville, MD 20850 (US). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> NI, Jian [CN/US]; 5502 Manorfield Road, Rockville, MD 20853 (US). YU, Guo-Liang [CN/US]; 13524 Straw Bale Lane, Darnestown, MD 20878 (US). FAN, Ping [CN/US]; Apartment 302, 335 West Side Drive, Gaithersburg, MD 20878 (US). GENTZ, Reiner, L. [US/US]; 13404 Fairland Park Drive, Silver Spring, MD 20904 (US). <b>(74) Agents:</b> HOOVER, Kenley, K. et al.; Human Genome Sciences, Inc., 9410 Key West Avenue, Rockville, MD 20850 (US).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
<b>(54) Title:</b> HUMAN TUMOR NECROSIS FACTOR RECEPTOR TR9  <b>(57) Abstract</b>  The present invention relates to a novel member of the tumor necrosis factor family of receptors. In particular, isolated nucleic acid molecules are provided encoding the human TR9 receptor. TR9 polypeptides are also provided as are vectors, host cells and recombinant methods for producing the same. The invention further relates to screening methods for identifying agonists and antagonists of TR9 receptor activity.		

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## Human Tumor Necrosis Factor Receptor TR9

### *Field of the Invention*

The present invention relates to a novel member of the tumor necrosis factor family of receptors. More specifically, isolated nucleic acid molecules are provided encoding a novel human tumor necrosis factor receptor, TR9 (also known as Death Domain Containing Receptor 6, or simply DR6). TR9 polypeptides are also provided, as are vectors, host cells and recombinant methods for producing the same. The invention further relates to screening methods for identifying agonists and antagonists of TR9 activity.

### *Background of the Invention*

Many biological actions, for instance, response to certain stimuli and natural biological processes, are controlled by factors, such as cytokines. Many cytokines act through receptors by engaging the receptor and producing an intra-cellular response.

For example, tumor necrosis factors (TNF) alpha and beta are cytokines, which act through TNF receptors to regulate numerous biological processes, including protection against infection and induction of shock and inflammatory disease. The TNF molecules belong to the "TNF-ligand" superfamily, and act together with their receptors or counter-ligands, the "TNF-receptor" superfamily. So far, nine members of the TNF ligand superfamily have been identified and ten members of the TNF-receptor superfamily have been characterized.

Among the ligands there are included TNF- $\alpha$ , lymphotoxin- $\alpha$  (LT- $\alpha$ , also known as TNF- $\beta$ ), LT- $\beta$  (found in complex heterotrimer LT- $\alpha$ 2- $\beta$ ), FasL, CD40L, CD27L, CD30L, 4-1BBL, OX40L and nerve growth factor (NGF). The superfamily of TNF receptors includes the p55TNF receptor, p75TNF receptor, TNF receptor-related protein, FAS antigen or APO-1, CD40, CD27, CD30, 4-1BB, OX40, low affinity p75 and NGF-receptor (Meager, A., *Biologicals* 22:291-295 (1994)).

Many members of the TNF-ligand superfamily are expressed by activated T-cells, implying that they are necessary for T-cell interactions with other cell types which underlie cell ontogeny and functions. (Meager, A., *supra*).

5 Considerable insight into the essential functions of several members of the TNF receptor family has been gained from the identification and creation of mutants that abolish the expression of these proteins. For example, naturally occurring mutations in the FAS antigen and its ligand cause lymphoproliferative disease (Watanabe-Fukunaga. et al., *Nature* 356:314 (1992)), perhaps reflecting a failure of programmed cell death. Mutations of the CD40 ligand cause an X-linked  
10 immunodeficiency state characterized by high levels of immunoglobulin M and low levels of immunoglobulin G in plasma, indicating faulty T-cell-dependent B-cell activation (Allen et al., *Science* 259:990 (1993)). Targeted mutations of the low affinity nerve growth factor receptor cause a disorder characterized by faulty sensory innovation of peripheral structures (Lee et al., *Cell* 69:737 (1992)).

15 TNF and LT- $\alpha$  are capable of binding to two TNF receptors (the 55- and 75-kd TNF receptors). A large number of biological effects elicited by TNF and LT- $\alpha$ , acting through their receptors, include hemorrhagic necrosis of transplanted tumors, cytotoxicity, a role in endotoxic shock, inflammation, immunoregulation, proliferation and anti-viral responses, as well as protection against the deleterious effects of  
20 ionizing radiation. TNF and LT- $\alpha$  are involved in the pathogenesis of a wide range of diseases, including endotoxic shock, cerebral malaria, tumors, autoimmune disease, AIDS and graft-host rejection (Beutler et al., *Science* 264:667-668 (1994)). Mutations in the p55 receptor cause increased susceptibility to microbial infection.

Moreover, an about 80 amino acid domain near the C-terminus of TNFR1  
25 (p55) and Fas was reported as the "death domain," which is responsible for transducing signals for programmed cell death (Tartaglia et al., *Cell* 74:845 (1993)).

Apoptosis, or programmed cell death, is a physiologic process essential to the normal development and homeostasis of multicellular organisms (Steller, *Science*

267:1445-1449 (1995)). Derangements of apoptosis contribute to the pathogenesis of several human diseases including cancer, neurodegenerative disorders, and acquired immune deficiency syndrome (Thompson C. B., *Science* 267:1456-1462 (1995)). Recently, much attention has focused on the signal transduction and biological function of two cell surface death receptors, Fas/APO-1 and TNFR-1 (Cleveland et al., *Cell* 81:479-482 (1995); Fraser et al., *Cell* 85:781-784 (1996); S. Nagata et al., *Science* 267:1449-56 (1995)). Both are members of the TNF receptor family, which also include TNFR-2, low affinity NGFR, CD40, and CD30, among others (Smith et al., *Science* 248:1019-23 (1990); Tewari et al., in *Modular Texts in Molecular and Cell Biology*; M. Purton, Heldin, Carl, Ed. (Chapman and Hall, London, 1995). While family members are defined by the presence of cysteine-rich repeats in their extracellular domains, Fas/APO-1 and TNFR-1 also share a region of intracellular homology, appropriately designated the "death domain," which is distantly related to the *Drosophila* suicide gene, *reaper* (Golstein et al., *Cell* 81:185-6 (1995); White et al., *Science* 264:677-83 (1994)). This shared death domain suggests that both receptors interact with a related set of signal transducing molecules that, until recently, remained unidentified. Activation of Fas/APO-1 recruits the death domain-containing adapter molecule FADD/MORT1 (Chinnaiyan et al., *Cell* 81:505-512 (1995); Boldin et al., *J. Biol. Chem.* 270:7795-8 (1995); Kischkel et al., *EMBO* 14:5579-5588 (1995)), which in turn binds and presumably activates FLICE/MACH1, a member of the ICE/CED-3 family of pro-apoptotic proteases (Muzio et al., *Cell* 85:817-827 (1996); Boldin et al., *Cell* 85:803-815 (1996)). While the central role of Fas/APO-1 is to trigger cell death, TNFR-1 can signal an array of diverse biological activities-many of which stem from its ability to activate NF-kB (Tartaglia et al., *Immunol Today* 13:151-153 (1992)). Accordingly, TNFR-1 recruits the multivalent adapter molecule TRADD, which like FADD, also contains a death domain (Hsu et al., *Cell* 81:495-504 (1995); Hsu et al., *Cell* 84:299-308 (1996)). Through its associations with a number of signaling molecules including FADD, TRAF2, and RIP, TRADD can signal both apoptosis and NF-kB activation (Hsu et al., *Cell* 84:299-308 (1996); Hsu et al., *Immunity* 4:387-396

(1996)).

The effects of TNF family ligands and receptors are varied and influence numerous functions, both normal and abnormal, in the biological processes of the mammalian system. There is a clear need, therefore, for identification and characterization of additional novel TNF receptors and ligands that influence biological activity, both normally and in disease states.

### *Summary of the Invention*

The present invention provides isolated nucleic acid molecules comprising a polynucleotide encoding the TR9 receptor having the amino acid sequence shown in Figures 1A-D (SEQ ID NO:2) or the amino acid sequence encoded by the cDNA clone deposited as ATCC Deposit Number 209037 on May 15, 1997.

The present invention also relates to recombinant vectors, which include the isolated nucleic acid molecules of the present invention, and to host cells containing the recombinant vectors, as well as to methods of making such vectors and host cells and for using them for production of TR9 receptor polypeptides or peptides by recombinant techniques.

The invention further provides an isolated TR9 polypeptide having an amino acid sequence encoded by a polynucleotide described herein.

The present invention also provides a screening method for identifying compounds capable of enhancing or inhibiting a cellular response induced by the TR9 receptor. The method involves contacting cells which express the TR9 receptor with the candidate compound, assaying a cellular response, and comparing the cellular response to a standard cellular response, the standard being assayed when contact is made in absence of the candidate compound; whereby, an increased cellular response over the standard indicates that the compound is an agonist and a decreased cellular response over the standard indicates that the compound is an antagonist.

The invention further provides diagnostic assays such as quantitative and diagnostic assays for detecting levels of TR9 receptor protein. Thus, for instance, a

diagnostic assay in accordance with the invention for detecting over-expression of TR9, or soluble form thereof, compared to normal control tissue samples, may be used to detect the presence of tumors.

5 Tumor Necrosis Factor (TNF) family ligands are known to be among the most pleiotropic cytokines, inducing a large number of cellular responses, including cytotoxicity, anti-viral activity, immunoregulatory activities, and the transcriptional regulation of several genes. Cellular response to TNF-family ligands include not only normal physiological responses, but also diseases associated with increased apoptosis or the inhibition of apoptosis. Apoptosis-programmed cell death is a physiological  
10 mechanism involved in the deletion of peripheral T lymphocytes of the immune system, and its dysregulation can lead to a number of different pathogenic processes. Diseases associated with increased cell survival, or the inhibition of apoptosis, include cancers, autoimmune disorders, viral infections, inflammation, graft vs. host disease, acute graft rejection, and chronic graft rejection. Diseases associated with increased  
15 apoptosis include AIDS, neurodegenerative disorders, myelodysplastic syndromes, ischemic injury, toxin-induced liver disease, septic shock, cachexia, and anorexia.

Thus, the invention further provides a method for enhancing apoptosis induced by a TNF-family ligand, which involves administering to a cell which expresses the TR9 polypeptide an effective amount of an agonist capable of increasing  
20 TR9 mediated signaling. Preferably, TR9 mediated signaling is increased to treat a disease wherein decreased apoptosis is exhibited.

In a further aspect, the present invention is directed to a method for inhibiting apoptosis induced by a TNF-family ligand, which involves administering to a cell which expresses the TR9 polypeptide an effective amount of an antagonist capable of  
25 decreasing TR9 mediated signaling. Preferably, TR9 mediated signaling is decreased to treat a disease wherein increased apoptosis is exhibited.

*Brief Description of the Figures*

**Figures 1A-D** shows the nucleotide sequence (SEQ ID NO:1) and deduced amino acid sequence (SEQ ID NO:2) of the TR9 receptor. Analysis using the computer program PSORT reveals that the protein has a predicted leader sequence of about 40 amino acid residues (underlined) and a deduced molecular weight of about 72 kDa. It is further predicted that amino acid residues from about 41 to about 350 constitute the extracellular domain (amino acid residues from about 1 to about 310 in SEQ ID NO:2); from about 351 to about 367 the transmembrane domain (amino acid residues from about 311 to about 327 in SEQ ID NO:2); from about 368 to about 655 the intracellular domain (amino acid residues from about 328 to about 615 in SEQ ID NO:2); and from about 429 to about 495 the death domain (amino acid residues from about 389 to about 455 in SEQ ID NO:2).

**Figure 2** shows the regions of similarity between the amino acid sequences of the TR9 receptor protein and Fas (SEQ ID NO:3), NGFR p75 (SEQ ID NO:4), and TNFR 1 (SEQ ID NO:5).

**Figure 3** shows an analysis of the TR9 amino acid sequence. Alpha, beta, turn and coil regions; hydrophilicity and hydrophobicity; amphipathic regions; flexible regions; antigenic index and surface probability are shown. In the "Antigenic Index - Jameson-Wolf" graph, amino acid residues about 44 to about 121, about 156 to about 311, about 323 to about 348, about 376 to about 412, about 433 to about 474, about 485 to about 599, and about 611 to about 628 in Figures 1A-D correspond to the shown highly antigenic regions of the TR9 protein. These highly antigenic fragments in Figures 1A-D correspond to the following fragments, respectively, in SEQ ID NO:2: amino acid residues about 4 to about 81, about 116 to about 271, about 283 to about 308, about 336 to about 372, about 393 to about 434, about 445 to about 559, and about 571 to about 588.

**Figures 4A-C.** Highlights of the predicted amino acid sequence of TR9.



Figure 4A: The open reading frame for TR9 defines a type I transmembrane protein of 655 amino acids (SEQ ID NO:2). Application of a computer program other than PSORT has predicted the mature protein to start at amino acid 42 (Gln, indicated by a black triangle). The putative signal peptide and transmembrane domain are single and double underlined, respectively. Six potential N-glycosylation sites are indicated by black dots. The cytoplasmic death domain is boxed. An intracellular region containing a potential leucine-zipper motif overlapping with a proline rich sequence is underlined with a thick line. Figure 4B: Sequence alignment of extracellular cysteine-rich domains of TR9 (SEQ ID NO:19) and osteoprotegrin (SEQ ID NO:20). Alignment was done with Megalign (DNASTAR) software. Shading represents identical residues. Figure 4C: Sequence comparison of death domains of TR9 (SEQ ID NO:21), CD95 (SEQ ID NO:22), TNFR1 (SEQ ID NO:23), DR3 (SEQ ID NO:24), DR4 (SEQ ID NO:25), and DR5 (SEQ ID NO:26). Alignment was performed and represented in the same way as in Figure 4B. OPG; osteoprotegerin.

**Figure 5.** TR9 induces apoptosis in mammalian cells. Ectopic expression of TR9 induces apoptosis in Hela cells, but not in MCF7 cells. Hela and MCF7 cells were cotransfected with a empty vector, TR9, TR9 delta, or DR4, together with a  $\beta$ -galactosidase-expressing reporter construct using a lipofectamine method according to the manufacturer's instructions (BRL). Nineteen hours after transfection, cells were stained with 5-bromo-4-chloro-3-indoxyl- $\beta$ -D-galactopyranoside (X-Gal) and examined as described in Chinnaiyan et al., *Cell* 81:505-512 (1995). The data (mean  $\pm$  SD) represent the percentage of round, apoptotic cells as a function of total  $\beta$ -galactosidase-positive cells (n=4).

**Figure 6.** TR9 mediates nuclear factor kB activation. Cotransfection of 293 cells was performed with the indicated expression constructs and a NF-kB luciferase reporter

construct. After transfection (at 36 hours), cell extracts were prepared and luciferase activities determined as previously described (Chinnaiyan et al., *Science* 274:990-992 (1996); and Pan et al., *Science* 276:111-113 (1997)). Transfection efficiency was monitored by  $\beta$ -galactosidase activity. A portion of the transfected cells was used to  
5 monitor expression of TR9 or TR9 delta. Cell lysates were prepared and immunoprecipitated with FLAG M2 affinity gel and the presence of TR9 or TR9 delta detected by blotting with anti-FLAG.

### *Detailed Description of the Preferred Embodiments*

10 The present invention provides isolated nucleic acid molecules comprising a polynucleotide encoding a TR9 receptor polypeptide having the amino acid sequence shown in Figures 1A-C (SEQ ID NO:2), which was determined by sequencing a cloned cDNA. As shown in Figure 2, the TR9 receptor protein of the present invention shares sequence homology with Fas (SEQ ID NO:3), NGFR p75 (SEQ ID  
15 NO:4), and TNFR 1(SEQ ID NO:5). The nucleotide sequence shown in SEQ ID NO:1 was obtained by sequencing a cDNA clone, which was deposited on May 15, 1997 at the American Type Culture Collection, 12301 Park Lawn Drive, Rockville, Maryland 20852, and given accession number 209037. The deposited clone is inserted in the pBluescript SK(-) plasmid (Stratagene, LaJolla, CA) using the EcoRI  
20 and XhoI restriction endonuclease cleavage sites.

### *Nucleic Acid Molecules*

Unless otherwise indicated, all nucleotide sequences determined by sequencing a DNA molecule herein were determined using an automated DNA sequencer (such as  
25 the Model 373 from Applied Biosystems, Inc.), and all amino acid sequences of polypeptides encoded by DNA molecules determined herein were predicted by translation of a DNA sequence determined as above. Therefore, as is known in the art for any DNA sequence determined by this automated approach, any nucleotide

sequence determined herein may contain some errors. Nucleotide sequences determined by automation are typically at least about 90% identical, more typically at least about 95% to at least about 99.9% identical to the actual nucleotide sequence of the sequenced DNA molecule. The actual sequence can be more precisely determined by other approaches including manual DNA sequencing methods well known in the art. As is also known in the art, a single insertion or deletion in a determined nucleotide sequence compared to the actual sequence will cause a frame shift in translation of the nucleotide sequence such that the predicted amino acid sequence encoded by a determined nucleotide sequence will be completely different from the amino acid sequence actually encoded by the sequenced DNA molecule, beginning at the point of such an insertion or deletion.

Using the information provided herein, such as the nucleotide sequence in Figures 1A-D (SEQ ID NO:1), a nucleic acid molecule of the present invention encoding a TR9 polypeptide may be obtained using standard cloning and screening procedures, such as those for cloning cDNAs using mRNA as starting material. Illustrative of the invention, the nucleic acid molecule described in Figures 1A-D (SEQ ID NO:1) was discovered in a cDNA library derived from human microvascular endothelial cells. The gene was also identified in cDNA libraries from the following tissues: human placenta, stromal cells, human amygdala, human umbilical vein endothelial cells, kidney cancer, human gall bladder, soares adult brain, normal human liver, hepatocellular tumor, keratinocytes, bone marrow, macrophage, human synovial sarcoma, human hippocampus, and human tonsils.

The determined nucleotide sequence of the TR9 cDNA of Figures 1A-D (SEQ ID NO:1) contains an open reading frame encoding a protein of about 615 amino acid residues, with a predicted leader sequence of about 40 amino acid residues, and a deduced molecular weight of about 72 kDa. The amino acid sequence of the predicted mature TR9 receptor is shown in Figures 1A-D (SEQ ID NO:2) from amino acid residue about 1 to residue about 615. The TR9 protein shown in Figures 1A-D (SEQ ID NO:2) is about 24% identical and about 43% similar to NGFR (Figure 2).

As predicted by the sequence homology exhibited between TR9 and other death domain containing receptors (see Figure 4C), TR9 induces of mammalian cells apoptosis (see Figure 6). It is expected that TR9-induced apoptosis will be efficiently blocked by inhibitors of death proteases including z-VAD-fmk, an irreversible broad spectrum caspase inhibitor and CrmA, a cowpox virus encoded serpin that preferentially inhibits apical caspases such as FLICE/MACH-1 (caspase-8).

As indicated, the present invention also provides the mature form(s) of the TR9 receptor of the present invention. According to the signal hypothesis, proteins secreted by mammalian cells have a signal or secretory leader sequence which is cleaved from the mature protein once export of the growing protein chain across the rough endoplasmic reticulum has been initiated. Most mammalian cells and even insect cells cleave secreted proteins with the same specificity. However, in some cases, cleavage of a secreted protein is not entirely uniform, which results in two or more mature species on the protein. Further, it has long been known that the cleavage specificity of a secreted protein is ultimately determined by the primary structure of the complete protein, that is, it is inherent in the amino acid sequence of the polypeptide. Therefore, the present invention provides a nucleotide sequence encoding the mature TR9 receptor polypeptides having the amino acid sequence encoded by the cDNA clone contained in the host identified as ATCC Deposit No. 209037 and as shown in Figures 1A-D (SEQ ID NO:2). By the mature TR9 protein having the amino acid sequence encoded by the cDNA clone contained in the host identified as ATCC Deposit 209037 is meant the mature form(s) of the TR9 receptor produced by expression in a mammalian cell (e.g., COS cells, as described below) of the complete open reading frame encoded by the human DNA sequence of the clone contained in the vector in the deposited host. As indicated below, the mature TR9 receptor having the amino acid sequence encoded by the cDNA clone contained in ATCC Deposit No. 209037 may or may not differ from the predicted "mature" TR9 receptor protein shown in SEQ ID NO:2 (amino acids from about 1 to about 615) depending on the accuracy of the predicted cleavage site based on computer analysis.

Methods for predicting whether a protein has a secretory leader as well as the cleavage point for that leader sequence are available. For instance, the methods of McGeoch (*Virus Res.* 3:271-286 (1985)) and von Heinje (*Nucleic Acids Res.* 14:4683-4690 (1986)) can be used. The accuracy of predicting the cleavage points of known mammalian secretory proteins for each of these methods is in the range of 75-80%.  
5 von Heinje, *supra*. However, the two methods do not always produce the same predicted cleavage point(s) for a given protein.

In the present case, the predicted amino acid sequence of the complete TR9 polypeptides of the present invention were analyzed by a computer program ("PSORT") (K. Nakai and M. Kanehisa, *Genomics* 14:897-911 (1992)), which is an expert system for predicting the cellular location of a protein based on the amino acid sequence. As part of this computational prediction of localization, the methods of McGeoch and von Heinje are incorporated. The analysis by the PSORT program predicted the cleavage site between amino acid residues 40 and 41 in Figures 1A-D  
10 (amino acid residues -1 and 1 in SEQ ID NO:2). Thereafter, the complete amino acid sequences were further analyzed by visual inspection, applying a simple form of the (-1,-3) rule of von Heinje. von Heinje, *supra*. Thus, the leader sequence for the TR9 receptor protein is predicted to consist of amino acid residues from about 1 to 40 in Figures 1A-D (amino acid residues -40 to about -1 in SEQ ID NO:2), while the mature TR9 protein is predicted to consist of residues from about 41 to 655 in Figures 1A-D  
15 (about 1 to about 615 of SEQ ID NO:2). Analysis using a different computer program predicts that the mature protein of TR9 starts at amino acid 42 (Gln) as depicted in Figures 1A-D and 4A. The results of this analysis are presented in Figure 4A and described in Example 6.

25 As one of ordinary skill would appreciate, due to the possibility of sequencing errors, as well as the variability of cleavage sites for leaders in different known proteins, the predicted TR9 receptor polypeptide encoded by the deposited cDNA comprises about 655 amino acids, but may be anywhere in the range of 645-665 amino acids; and the predicted leader sequence of this protein is about 40 amino acids, but

may be anywhere in the range of about 30 to about 50 amino acids.

As indicated, nucleic acid molecules of the present invention may be in the form of RNA, such as mRNA, or in the form of DNA, including, for instance, cDNA and genomic DNA obtained by cloning or produced synthetically. The DNA may be double-stranded or single-stranded. Single-stranded DNA or RNA may be the coding strand, also known as the sense strand, or it may be the non-coding strand, also referred to as the anti-sense strand.

By "isolated" nucleic acid molecule(s) is intended a nucleic acid molecule, DNA or RNA, which has been removed from its native environment. For example, recombinant DNA molecules contained in a vector are considered isolated for the purposes of the present invention. Further examples of isolated DNA molecules include recombinant DNA molecules maintained in heterologous host cells or purified (partially or substantially) DNA molecules in solution. Isolated RNA molecules include *in vivo* or *in vitro* RNA transcripts of the DNA molecules of the present invention. Isolated nucleic acid molecules according to the present invention further include such molecules produced synthetically.

Isolated nucleic acid molecules of the present invention include DNA molecules comprising an open reading frame (ORF) shown in Figures 1A-D (SEQ ID NO:1); DNA molecules comprising the coding sequence for the mature TR9 protein; and DNA molecules which comprise a sequence substantially different from those described above but which, due to the degeneracy of the genetic code, still encode the TR9 protein shown in Figures 1A-D (SEQ ID NO:2). Of course, the genetic code is well known in the art. Thus, it would be routine for one skilled in the art to generate such degenerate variants.

In addition, the invention provides nucleic acid molecules having nucleotide sequences related to extensive portions of the nucleotide sequence in Figures 1A-D of (SEQ ID NO:1), which have been determined from the following related cDNA clones: HIBEJ86R (SEQ ID NO:6), HL1AA79R (SEQ ID NO:7), HHFGD57R (SEQ ID NO:8), HSABG38R (SEQ ID NO:9), and HHPDZ31R (SEQ ID NO:10).

Further, the invention includes a polynucleotide comprising any portion of at least about 30 nucleotides, preferably at least about 50 nucleotides, of the nucleotide sequence disclosed in Figures 1A-D from nucleotides 655 to 907 (nucleotides 615 to 867 of SEQ ID NO:1) and/or the nucleotide sequence disclosed in Figures 1A-D from  
5 nucleotides to 540 to 1020 (nucleotides 500 to 980 as depicted in SEQ ID NO:1).

In another aspect, the invention provides isolated nucleic acid molecules encoding the TR9 receptor polypeptide having an amino acid sequence as encoded by the cDNA clone contained in the plasmid deposited as ATCC Deposit No. 209037 on May 15, 1997. In a further embodiment, nucleic acid molecules are provided encoding  
10 the mature TR9 receptor polypeptide or the full-length TR9 receptor polypeptide lacking the N-terminal methionine. The invention also provides an isolated nucleic acid molecule having the nucleotide sequence shown in Figures 1A-D (SEQ ID NO:1) or the nucleotide sequence of the TR9 cDNA contained in the above-described deposited clone, or a nucleic acid molecule having a sequence complementary to one of  
15 the above sequences. Such isolated molecules, particularly DNA molecules, are useful as probes for gene mapping, by *in situ* hybridization with chromosomes, and for detecting expression of the TR9 receptor gene in human tissue, for instance, by Northern blot analysis.

The present invention is further directed to fragments of the isolated nucleic acid molecules described herein. By a fragment of an isolated nucleic acid molecule having the nucleotide sequence of the deposited cDNA, or the nucleotide sequence shown in Figures 1A-D (SEQ ID NO:1), or the complementary strand thereto, is intended fragments at least about 15 nt, and more preferably at least about 20 nt, still more preferably at least about 30 nt, and even more preferably, at least about 40, 50,  
20 100, 150, 200, 250, 300, 400, or 500 nt in length. These fragments have numerous uses which include, but are not limited to, diagnostic probes and primers as discussed herein. Of course, larger fragments 50-1500 nt in length are also useful according to the present invention as are fragments corresponding to most, if not all, of the nucleotide sequence of the deposited cDNA or as shown in Figures 1A-D (SEQ ID  
25

NO:1). By a fragment at least 20 nt in length, for example, is intended fragments which include 20 or more contiguous bases from the nucleotide sequence of the deposited cDNA or the nucleotide sequence as shown in Figures 1A-D (SEQ ID NO:1).

5           Representative examples of TR9 polynucleotide fragments of the invention include, for example, fragments that comprise, or alternatively, consist of, a sequence from about nucleotide 1-50, 51-100, 101-150, 151-200, 201-250, 251-300, 301-350, 351-400, 401-450, 445-879, 451-500, 501-550, 551-600, 615-651, 651-700, 701-750, 751-800, 800-850, 850-867, 851-900, 901-950, 951-1000, 1001-1050, 1051-1100, 10  
1101-1150, 1151-1200, 1201-1250, 1251-1300, 1301-1350, 1351-1400, 1401-1450, 1451-1500, 1501-1550, 1551-1600, 1601-1650, 1651-1700, 1701-1750, 1751-1800, 1801-1850, 1851-1900, 1901-1950, 1951-2000, 2001-2050, 2051-3000, or 3001 to the end of SEQ ID NO:1, or the complementary DNA strand thereto, or the cDNA contained in the deposited clone. In this context "about" includes the particularly  
15           recited ranges, larger or smaller by several (5, 4, 3, 2, or 1) nucleotides, at either terminus or at both termini. In specific embodiments, the polynucleotide fragments of the invention encode a polypeptide which demonstrates a functional activity. By a polypeptide demonstrating "functional activity" is meant, a polypeptide capable of displaying one or more known functional activities associated with a complete or  
20           mature TR9 polypeptide. Such functional activities include, but are not limited to, biological activity, antigenicity [ability to bind (or compete with a TR9 polypeptide for binding) to an anti-TR9 antibody], immunogenicity (ability to generate antibody which binds to a TR9 polypeptide), and ability to bind to a receptor or ligand for a TR9 polypeptide.

25           Preferred nucleic acid fragments of the present invention include nucleic acid molecules encoding: a polypeptide comprising the TR9 receptor extracellular domain (predicted to constitute amino acid residues from about 1 to about 310 in SEQ ID NO:2); a polypeptide comprising the four TNFR-like cysteine rich motifs of TR9 (amino acid residues 67 to 211 in Figures 1A-D; amino acid residues 27 to 171 in SEQ



ID NO:2), a polypeptide comprising the TR9 receptor transmembrane domain (predicted to constitute amino acid residues from about 311 to about 327 in SEQ ID NO:2); a polypeptide comprising the TR9 receptor intracellular domain (predicted to constitute amino acid residues from about 328 to about 615 in SEQ ID NO:2); a polypeptide comprising the TR9 receptor extracellular and intracellular domains with all or part of the transmembrane domain deleted; a polypeptide comprising the TR9 receptor death domain (predicted to constitute amino acid residues from about 389 to about 455 in SEQ ID NO:2); and nucleic acid molecules encoding epitope bearing portions of the TR9 receptor protein. As above, with the leader sequence, the amino acid residues constituting the TR9 receptor extracellular, transmembrane and intracellular domains have been predicted by computer analysis. Thus, as one of ordinary skill would appreciate, the amino acid residues constituting these domains may vary slightly (e.g., by about 1 to about 15 amino acid residues) depending on the criteria used to define each domain.

Preferred nucleic acid fragments of the present invention also include nucleic acid molecules encoding one or more epitope-bearing portions of the TR9 receptor protein. In particular, such nucleic acid fragments of the present invention include nucleic acid molecules encoding: a polypeptide comprising amino acid residues from about 4 to about 81 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 116 to about 271 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 283 to about 308 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 336 to about 372 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 393 to about 434 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 445 to about 559 in SEQ ID NO:2; and a polypeptide comprising amino acid residues from about 571 to about 588 in SEQ ID NO:2. The inventors have determined that the above polypeptide fragments are antigenic regions of the TR9 receptor. Methods for determining other such epitope-bearing portions of the TR9 protein are described in detail below.

In another aspect, the invention provides an isolated nucleic acid molecule

comprising a polynucleotide which hybridizes, preferably under stringent hybridization conditions, to a portion of the polynucleotide sequence of a polynucleotide of the invention such as, for instance, the cDNA clone contained in ATCC Deposit 209037. By "stringent hybridization conditions" is intended  
5 overnight incubation at 42°C in a solution comprising: 50% formamide, 5x SSC (150 mM NaCl, 15mM trisodium citrate), 50 mM sodium phosphate (pH 7.6), 5x Denhardt's solution, 10% dextran sulfate, and 20 g/ml denatured, sheared salmon sperm DNA, followed by washing the filters in 0.1x SSC at about 65°C.

By a polynucleotide which hybridizes to a "portion" of a polynucleotide is  
10 intended a polynucleotide (either DNA or RNA) hybridizing to at least about 15 nucleotides (nt), and more preferably at least about 20 nt, still more preferably at least about 30 nt, and even more preferably about 30-70, or 80-150 nt, or the entire length of the reference polynucleotide. These are useful as diagnostic probes and primers as discussed above and in more detail below.

15 In specific embodiments, polynucleotides of the invention hybridize to a complementary strand of a polynucleotide encoding amino acid residues 40-152, 40-48, 40-51, 51-66, 66-73, 73-83, 83-104, 104-110, 110-128, 128-146, and/or 146-152 as depicted in SEQ ID NO:2.

By a portion of a polynucleotide of "at least 20 nt in length," for example, is  
20 intended 20 or more contiguous nucleotides from the nucleotide sequence of the reference polynucleotide (e.g., the deposited cDNA or the nucleotide sequence as shown in Figures 1A-D (SEQ ID NO:1)).

Of course, a polynucleotide which hybridizes only to a poly A sequence (such as the 3' terminal poly tract of the TR9 receptor cDNA shown in SEQ ID NO:1), or  
25 to a complementary stretch of T (or U) residues, would not be included in a polynucleotide of the invention used to hybridize to a portion of a nucleic acid of the invention, since such a polynucleotide would hybridize to any nucleic acid molecule containing a poly (A) stretch or the complement thereof (e.g., practically any double-

stranded cDNA clone generated using oligo dT as a primer).

As indicated, nucleic acid molecules of the present invention which encode a TR9 receptor polypeptide may include, but are not limited to, those encoding the amino acid sequence of the mature polypeptide, by itself; the coding sequence for the mature polypeptide and additional sequences, such as those encoding the about amino acid leader or secretory sequence, such as a pre-, or pro- or prepro- protein sequence; the coding sequence of the mature polypeptide, with or without the aforementioned additional coding sequences, together with additional, non-coding sequences, including for example, but not limited to introns and non-coding 5' and 3' sequences, such as the transcribed, non-translated sequences that play a role in transcription, mRNA processing, including splicing and polyadenylation signals, for example - ribosome binding and stability of mRNA; an additional coding sequence which codes for additional amino acids, such as those which provide additional functionalities. Thus, the sequence encoding the polypeptide may be fused to a marker sequence, such as a sequence encoding a peptide which facilitates purification of the fused polypeptide. In certain preferred embodiments of this aspect of the invention, the marker amino acid sequence is a hexa-histidine peptide, such as the tag provided in a pQE vector (Qiagen, Inc.), among others, many of which are commercially available. As described in Gentz et al., *Proc. Natl. Acad. Sci. USA* 86:821-824 (1989), for instance, hexa-histidine provides for convenient purification of the fusion protein. The "HA" tag is another peptide useful for purification which corresponds to an epitope derived from the influenza hemagglutinin protein, which has been described by Wilson et al., *Cell* 37:767-778 (1984). As discussed below, other such fusion proteins include the TR9 receptor fused to Fc at the N- or C-terminus.

The present invention further relates to variants of the nucleic acid molecules of the present invention, which encode portions, analogs or derivatives of the TR9 receptor. Variants may occur naturally, such as a natural allelic variant. By an "allelic variant" is intended one of several alternate forms of a gene occupying a given locus on a chromosome of an organism. *Genes II*, Lewin, B., ed., John Wiley & Sons, New

York (1985). Non-naturally occurring variants may be produced using art-known mutagenesis techniques.

Such variants include those produced by nucleotide substitutions, deletions or additions, which may involve one or more nucleotides. The variants may be altered in coding regions, non-coding regions, or both. Alterations in the coding regions may produce conservative or non-conservative amino acid substitutions, deletions or additions. Especially preferred among these are silent substitutions, additions and deletions, which do not alter the properties and activities of the TR9 receptor or portions thereof. Also especially preferred in this regard are conservative substitutions.

Further embodiments of the invention include isolated nucleic acid molecules comprising a polynucleotide having a nucleotide sequence at least 90% identical, and more preferably at least 95%, 96%, 97%, 98% or 99% identical to (a) a nucleotide sequence encoding the polypeptide having the amino acid sequence shown in Figures 1A-D (SEQ ID NO:2); (b) a nucleotide sequence encoding the polypeptide having the amino acid sequence shown in Figures 1A-D (SEQ ID NO:2), but lacking the N-terminal methionine; (c) a nucleotide sequence encoding the predicted mature TR9 polypeptide (full-length polypeptide with any attending leader sequence removed) comprising the amino acid sequence at positions from about 1 to about 615 in SEQ ID NO:2; (d) a nucleotide sequence encoding the TR9 polypeptide having the amino acid sequence encoded by the cDNA clone contained in ATCC Deposit No. 209037; (e) a nucleotide sequence encoding the mature TR9 polypeptide having the amino acid sequence encoded by the cDNA clone contained in ATCC Deposit No. 209037; (f) a nucleotide sequence encoding the TR9 receptor extracellular domain; (g) a nucleotide sequence encoding the four TNFR-like cysteine rich motifs of TR9 (amino acid residues 67 to 211 in Figures 1A-D; amino acid residues 27 to 171 in SEQ ID NO:2); (h) a nucleotide sequence encoding the TR9 receptor transmembrane domain; (i) a nucleotide sequence encoding the TR9 receptor intracellular domain; (j) a nucleotide sequence encoding the TR9 receptor extracellular and intracellular domains with all or

part of the transmembrane domain deleted; (k) a nucleotide sequence encoding the TR9 receptor death domain; (l) a nucleotide sequence encoding the TR9 leucine zipper; and (m) a nucleotide sequence complementary to any of the nucleotide sequences in (a), (b), (c), (d), (e), (f), (g), (h), (i), (j), (k), or (l).

5 By a polynucleotide having a nucleotide sequence at least, for example, 95% "identical" to a reference nucleotide sequence encoding a TR9 receptor polypeptide is intended that the nucleotide sequence of the polynucleotide is identical to the reference sequence except that the polynucleotide sequence may include up to five point mutations per each 100 nucleotides of the reference nucleotide sequence  
10 encoding the TR9 receptor. In other words, to obtain a polynucleotide having a nucleotide sequence at least 95% identical to a reference nucleotide sequence, up to 5% of the nucleotides in the reference sequence may be deleted or substituted with another nucleotide, or a number of nucleotides up to 5% of the total nucleotides in the reference sequence may be inserted into the reference sequence. These mutations of  
15 the reference sequence may occur at the 5' or 3' terminal positions of the reference nucleotide sequence or anywhere between those terminal positions, interspersed either individually among nucleotides in the reference sequence or in one or more contiguous groups within the reference sequence. The reference (query) sequence may be the entire TR9 nucleotide sequence shown in Figures 1A-D (SEQ ID NO:1) or any  
20 fragment as described herein.

As a practical matter, whether any particular nucleic acid molecule is at least 90%, 95%, 96%, 97%, 98% or 99% identical to, for instance, the nucleotide sequence shown in Figures 1A-D (SEQ ID NO:1) or to the nucleotides sequence of the deposited cDNA clone can be determined conventionally using known computer  
25 programs such as the Bestfit program (Wisconsin Sequence Analysis Package, Version 8 for Unix, Genetics Computer Group, University Research Park, 575 Science Drive, Madison, WI 53711). Bestfit uses the local homology algorithm of Smith and Waterman, *Advances in Applied Mathematics* 2:482-489 (1981), to find the best segment of homology between two sequences. When using Bestfit or any other

sequence alignment program to determine whether a particular sequence is, for instance, 95% identical to a reference sequence according to the present invention, the parameters are set, of course, such that the percentage of identity is calculated over the full length of the reference nucleotide sequence and that gaps in homology of up to 5% of the total number of nucleotides in the reference sequence are allowed.

In a specific embodiment, the identity between a reference (query) sequence (a sequence of the present invention) and a subject sequence, also referred to as a global sequence alignment, is determined using the FASTDB computer program based on the algorithm of Brutlag et al. (Comp. App. Biosci. 6:237-245 (1990)). Preferred parameters used in a FASTDB alignment of DNA sequences to calculate percent identity are: Matrix=Unitary, k-tuple=4, Mismatch Penalty=1, Joining Penalty=30, Randomization Group Length=0, Cutoff Score=1, Gap Penalty=5, Gap Size Penalty 0.05, Window Size=500 or the length of the subject nucleotide sequence, whichever is shorter. According to this embodiment, if the subject sequence is shorter than the query sequence because of 5' or 3' deletions, not because of internal deletions, a manual correction is made to the results to take into consideration the fact that the FASTDB program does not account for 5' and 3' truncations of the subject sequence when calculating percent identity. For subject sequences truncated at the 5' or 3' ends, relative to the query sequence, the percent identity is corrected by calculating the number of bases of the query sequence that are 5' and 3' of the subject sequence, which are not matched/aligned, as a percent of the total bases of the query sequence. A determination of whether a nucleotide is matched/aligned is determined by results of the FASTDB sequence alignment. This percentage is then subtracted from the percent identity, calculated by the above FASTDB program using the specified parameters, to arrive at a final percent identity score. This corrected score is what is used for the purposes of this embodiment. Only bases outside the 5' and 3' bases of the subject sequence, as displayed by the FASTDB alignment, which are not matched/aligned with the query sequence, are calculated for the purposes of manually adjusting the percent identity score. For example, a 90 base subject sequence is

aligned to a 100 base query sequence to determine percent identity. The deletions occur at the 5' end of the subject sequence and therefore, the FASTDB alignment does not show a matched/alignment of the first 10 bases at 5' end. The 10 unpaired bases represent 10% of the sequence (number of bases at the 5' and 3' ends not matched/total number of bases in the query sequence) so 10% is subtracted from the percent identity score calculated by the FASTDB program. If the remaining 90 bases were perfectly matched the final percent identity would be 90%. In another example, a 90 base subject sequence is compared with a 100 base query sequence. This time the deletions are internal deletions so that there are no bases on the 5' or 3' of the subject sequence which are not matched/aligned with the query. In this case the percent identity calculated by FASTDB is not manually corrected. Once again, only bases 5' and 3' of the subject sequence which are not matched/aligned with the query sequence are manually corrected for. No other manual corrections are made for the purposes of this embodiment.

The present application is directed to nucleic acid molecules at least 90%, 95%, 96%, 97%, 98% or 99% identical to the nucleic acid sequence shown in Figures 1A-D (SEQ ID NO:1) or to the nucleic acid sequence of the deposited cDNA, irrespective of whether they encode a polypeptide having TR9 receptor activity. This is because even where a particular nucleic acid molecule does not encode a polypeptide having TR9 receptor activity, one of skill in the art would still know how to use the nucleic acid molecule, for instance, as a hybridization probe or a polymerase chain reaction (PCR) primer. Uses of the nucleic acid molecules of the present invention that do not encode a polypeptide having TR9 receptor activity include, *inter alia*, (1) isolating the TR9 receptor gene or allelic variants thereof in a cDNA library; (2) *in situ* hybridization (e.g., "FISH") to metaphase chromosomal spreads to provide precise chromosomal location of the TR9 receptor gene, as described in Verma *et al.*, *Human Chromosomes: A Manual of Basic Techniques*, Pergamon Press, N.Y. (1988); and (3) Northern Blot analysis for detecting TR9 receptor mRNA expression in specific tissues.

Preferred, however, are nucleic acid molecules having sequences at least 90%, 95%, 96%, 97%, 98% or 99% identical to the nucleic acid sequence shown in Figures 1A-D (SEQ ID NO:1), the nucleic acid sequence of the deposited cDNA, or fragments thereof, which do, in fact, encode a polypeptide having TR9 receptor activity. By "a polypeptide having TR9 receptor activity" is intended polypeptides exhibiting activity similar, but not necessarily identical, to an activity of the TR9 receptor of the invention (either the full-length protein or, preferably, the mature protein), as measured in a particular immunoassay and/or biological assay. For example, TR9 receptor activity can be measured using the cell death assays performed essentially as previously described (Chinnaiyan et al., *Cell* 81:505-512 (1995); Boldin et al., *J. Biol. Chem.* 270:7795-8(1995); Kischkel et al., *EMBO* 14:5579-5588 (1995); Chinnaiyan et al., *J. Biol. Chem.* 271:4961-4965 (1996)) and as set forth in Example 5 below. In MCF7 cells, plasmids encoding full-length TR9 or a candidate death domain containing receptor are co-transfected with the pLantern reporter construct encoding green fluorescent protein. Nuclei of cells transfected with TR9 will exhibit apoptotic morphology as assessed by DAPI staining. It is expected that like TNFR-1 and Fas/APO-1 (Muzio et al., *Cell* 85:817-827 (1996); Boldin et al., *Cell* 85:803-815 (1996); Tewari et al., *J. Biol. Chem.* 270:3255-60 (1995)), TR9-induced apoptosis will be blocked by the inhibitors of ICE-like proteases, CrmA and z-VAD-fmk. In addition, it is expected that apoptosis induced by TR9 will be blocked by dominant negative versions of FADD (FADD-DN) or FLICE (FLICE-DN/MACHa1C360S).

Of course, due to the degeneracy of the genetic code, one of ordinary skill in the art will immediately recognize that a large number of the nucleic acid molecules having a sequence at least 90%, 95%, 96%, 97%, 98%, or 99% identical to the nucleic acid sequence of the deposited cDNA or the nucleic acid sequence shown in Figures 1A-D (SEQ ID NO:1), or fragments thereof, will encode a polypeptide "having TR9 receptor activity." In fact, since degenerate variants of these nucleotide sequences all encode the same polypeptide, in many instances, this will be clear to the skilled artisan even without performing the above described assay. It will be further



recognized in the art that, for such nucleic acid molecules that are not degenerate variants, a reasonable number will also encode a polypeptide having TR9 receptor activity. This is because the skilled artisan is fully aware of amino acid substitutions that are either less likely or not likely to significantly effect protein function (e.g., replacing one aliphatic amino acid with a second aliphatic amino acid).

For example, guidance concerning how to make phenotypically silent amino acid substitutions is provided in J.U. Bowie et al., "Deciphering the Message in Protein Sequences: Tolerance to Amino Acid Substitutions," *Science* 247:1306-1310 (1990), wherein the authors indicate that proteins are surprisingly tolerant of amino acid substitutions.

#### ***Polynucleotide assays***

This invention is also related to the use of TR9 polynucleotides to detect complementary polynucleotides such as, for example, as a diagnostic reagent. Detection of a mutated form of TR9 associated with a dysfunction will provide a diagnostic tool that can add or define a diagnosis of a disease or susceptibility to a disease which results from under-expression over-expression or altered expression of TR9 or a soluble form thereof, such as, for example, tumors or autoimmune disease.

Individuals carrying mutations in the TR9 gene may be detected at the DNA level by a variety of techniques. Nucleic acids for diagnosis may be obtained from a patient's cells, such as from blood, urine, saliva, tissue biopsy and autopsy material. The genomic DNA may be used directly for detection or may be amplified enzymatically by using PCR prior to analysis. (Saiki et al., *Nature* 324:163-166 (1986)). RNA or cDNA may also be used in the same ways. As an example, PCR primers complementary to the nucleic acid encoding TR9 can be used to identify and analyze TR9 expression and mutations. For example, deletions and insertions can be detected by a change in size of the amplified product in comparison to the normal genotype. Point mutations can be identified by hybridizing amplified DNA to radiolabeled TR9 RNA or alternatively, radiolabeled TR9 antisense DNA sequences.

Perfectly matched sequences can be distinguished from mismatched duplexes by RNase A digestion or by differences in melting temperatures.

Sequence differences between a reference gene and genes having mutations also may be revealed by direct DNA sequencing. In addition, cloned DNA segments may be employed as probes to detect specific DNA segments. The sensitivity of such methods can be greatly enhanced by appropriate use of PCR or another amplification method. For example, a sequencing primer is used with double-stranded PCR product or a single-stranded template molecule generated by a modified PCR. The sequence determination is performed by conventional procedures with radiolabeled nucleotide or by automatic sequencing procedures with fluorescent-tags.

Genetic testing based on DNA sequence differences may be achieved by detection of alteration in electrophoretic mobility of DNA fragments in gels, with or without denaturing agents. Small sequence deletions and insertions can be visualized by high resolution gel electrophoresis. DNA fragments of different sequences may be distinguished on denaturing formamide gradient gels in which the mobilities of different DNA fragments are retarded in the gel at different positions according to their specific melting or partial melting temperatures (see, e.g., Myers et al., *Science* 230:1242 (1985)).

Sequence changes at specific locations also may be revealed by nuclease protection assays, such as RNase and S1 protection or the chemical cleavage method (e.g., Cotton et al., *Proc. Natl. Acad. Sci. USA* 85:4397-4401 (1985)).

Thus, the detection of a specific DNA sequence may be achieved by methods such as hybridization, RNase protection, chemical cleavage, direct DNA sequencing or the use of restriction enzymes, (e.g., restriction fragment length polymorphisms ("RFLP") and Southern blotting of genomic DNA.

In addition to more conventional gel-electrophoresis and DNA sequencing, mutations also can be detected by *in situ* analysis.

### ***Vectors and Host Cells***

The present invention also relates to vectors which include the isolated DNA molecules of the present invention, host cells which are genetically engineered with the recombinant vectors, or which are otherwise engineered to produce the polypeptides of the invention, and the production of TR9 receptor polypeptides, or fragments thereof, by recombinant techniques.

The polynucleotides may be joined to a vector containing a selectable marker for propagation in a host. Generally, a plasmid vector is introduced in a precipitate, such as a calcium phosphate precipitate, or in a complex with a charged lipid. If the vector is a virus, it may be packaged *in vitro* using an appropriate packaging cell line and then transduced into host cells.

In one embodiment, the DNA of the invention is operatively associated with an appropriate heterologous regulatory element (e.g., promoter or enhancer), such as, the phage lambda PL promoter, the *E. coli lac*, *trp*, and *tac* promoters, the SV40 early and late promoters and promoters of retroviral LTRs, to name a few. Other suitable promoters will be known to the skilled artisan.

In embodiments in which vectors contain expression constructs, these constructs will further contain sites for transcription initiation, termination and, in the transcribed region, a ribosome binding site for translation. The coding portion of the mature transcripts expressed by the constructs will preferably include a translation initiating at the beginning and a termination codon (UAA, UGA or UAG) appropriately positioned at the end of the polypeptide to be translated.

As indicated, the expression vectors will preferably include at least one selectable marker. Such markers include dihydrofolate reductase or neomycin resistance for eukaryotic cell culture and tetracycline or ampicillin resistance genes for culturing in *E. coli* and other bacteria. Representative examples of appropriate hosts include, but are not limited to, bacterial cells, such as *E. coli*, *Streptomyces* and *Salmonella typhimurium* cells; fungal cells, such as yeast cells; insect cells such as *Drosophila* S2 and *Spodoptera* Sf9 cells; animal cells such as CHO, COS and Bowes

melanoma cells; and plant cells. Appropriate culture mediums and conditions for the above-described host cells are known in the art.

Among vectors preferred for use in bacteria include pQE70, pQE60 and pQE-9, available from Qiagen; pBS vectors, Phagescript vectors, Bluescript vectors, pNH8A, pNH16a, pNH18A, pNH46A, available from Stratagene; and ptrc99a, pKK223-3, pKK233-3, pDR540, pRIT5 available from Pharmacia. Among preferred eukaryotic vectors are pWLNEO, pSV2CAT, pOG44, pXT1 and pSG available from Stratagene; and pSVK3, pBPV, pMSG and pSVL available from Pharmacia. Other suitable vectors will be readily apparent to the skilled artisan.

Selection of appropriate vectors and promoters for expression in a host cell is a well known procedure and the requisite techniques for expression vector construction, introduction of the vector into the host and expression in the host are routine skills in the art.

The present invention also relates to host cells containing the vector constructs discussed herein, and additionally encompasses host cells containing nucleotide sequences of the invention that are operably associated with one or more heterologous control regions (e.g., promoter and/or enhancer) using techniques known of in the art. The host cell can be a higher eukaryotic cell, such as a mammalian cell (e.g., a human derived cell), or a lower eukaryotic cell, such as a yeast cell, or the host cell can be a prokaryotic cell, such as a bacterial cell. The host strain may be chosen which modulates the expression of the inserted gene sequences, or modifies and processes the gene product in the specific fashion desired. Expression from certain promoters can be elevated in the presence of certain inducers; thus expression of the genetically engineered polypeptide may be controlled. Furthermore, different host cells have characteristics and specific mechanisms for the translational and post-translational processing and modification (e.g., phosphorylation, cleavage) of proteins. Appropriate cell lines can be chosen to ensure the desired modifications and processing of the foreign protein expressed.

Introduction of the construct into the host cell can be effected by calcium phosphate transfection, DEAE-dextran mediated transfection, cationic lipid-mediated transfection, electroporation, transduction, infection or other methods. Such methods are described in many standard laboratory manuals, such as Davis et al., *Basic Methods In Molecular Biology* (1986).

The polypeptide may be expressed in a modified form, such as a fusion protein (comprising the polypeptide joined via a peptide bond to a heterologous protein sequence (of a different protein)), and may include not only secretion signals, but also additional heterologous functional regions. Such a fusion protein can be made by ligating polynucleotides of the invention and the desired nucleic acid sequence encoding the desired amino acid sequence to each other, by methods known in the art, in the proper reading frame, and expressing the fusion protein product by methods known in the art. Alternatively, such a fusion protein can be made by protein synthetic techniques, e.g., by use of a peptide synthesizer. Thus, for instance, a region of additional amino acids, particularly charged amino acids, may be added to the N-terminus of the polypeptide to improve stability and persistence in the host cell, during purification, or during subsequent handling and storage. Additionally, peptide moieties may be added to the polypeptide to facilitate purification. Such regions may be removed prior to final preparation of the polypeptide. The addition of peptide moieties to polypeptides to engender secretion or excretion, to improve stability and to facilitate purification, among others, are familiar and routine techniques in the art.

A preferred fusion protein comprises a heterologous region from immunoglobulin that is useful to solubilize proteins. For example, EP-A-O 464 533 (Canadian counterpart 2045869) discloses fusion proteins comprising various portions of constant region of immunoglobulin molecules together with another human protein or part thereof. In many cases, the Fc part in a fusion protein is thoroughly advantageous for use in therapy and diagnosis and thus results, for example, in improved pharmacokinetic properties (EPA 0 232 262). On the other hand, for some uses it would be desirable to be able to delete the Fc part after the fusion protein has

been expressed, detected and purified in the advantageous manner described. This is the case when the Fc portion proves to be a hindrance to use in therapy and diagnosis, for example when the fusion protein is to be used as an antigen for immunizations. In drug discovery, for example, human proteins, such as the hIL5-receptor, have been fused with Fc portions for the purpose of high-throughput screening assays to identify antagonists of hIL-5. See, Bennett et al., *J. of Molec. Recognition* 8:52-58 (1995) and Johanson et al., *J. Biol. Chem.* 270:9459-9471 (1995).

The TR9 receptor can be recovered and purified from recombinant cell cultures by standard methods which include, but are not limited to, ammonium sulfate or ethanol precipitation, acid extraction, anion or cation exchange chromatography, phosphocellulose chromatography, hydrophobic interaction chromatography, affinity chromatography, hydroxylapatite chromatography and lectin chromatography. Most preferably, high performance liquid chromatography ("HPLC") is employed for purification.

Polypeptides of the present invention include naturally purified products, products of chemical synthetic procedures, and products produced by recombinant techniques from a prokaryotic or eukaryotic host, including, for example, bacterial, yeast, higher plant, insect and mammalian cells. Depending upon the host employed in a recombinant production procedure, the polypeptides of the present invention may be glycosylated or may be non-glycosylated. In addition, polypeptides of the invention may also include an initial modified methionine residue or alternatively, may be missing the N-terminal methionine, in some cases as a result of host-mediated processes.

TR9 receptor polynucleotides and polypeptides may be used in accordance with the present invention for a variety of applications, particularly those that make use of the chemical and biological properties of TR9. Among these are applications in treatment of tumors, resistance to parasites, bacteria and viruses, to induce proliferation of T-cells, endothelial cells and certain hematopoietic cells, to treat restenosis, graft vs. host disease, to regulate anti-viral responses and to prevent

certain autoimmune diseases after stimulation of TR9 by an agonist. Additional applications relate to diagnosis and to treatment of disorders of cells, tissues and organisms. These aspects of the invention are discussed further below.

5       ***TR9 Receptor Polypeptides and Fragments***

The invention further provides an isolated TR9 receptor polypeptide having the amino acid sequence encoded by the deposited cDNA, or the amino acid sequence in Figures 1A-D (SEQ ID NO:2), or a peptide or polypeptide comprising a portion of the above polypeptides.

10       The polypeptides of this invention may be membrane bound or may be in a soluble circulating form. Soluble peptides are defined by amino acid sequence wherein the sequence comprises the polypeptide sequence lacking the transmembrane domain.

15       The polypeptides of the present invention may exist as a membrane bound receptor having a transmembrane region and an intra- and extracellular region or they may exist in soluble form wherein the transmembrane domain is lacking. One example of such a form of the TR9 receptor is the TR9 receptor shown in Figures 1A-D (SEQ ID NO:2) which contains, in addition to a leader sequence, transmembrane, intracellular and extracellular domains. Thus, this form of the TR9 receptor appears to be localized in the cytoplasmic membrane of cells which express this protein.

20       It will be recognized in the art that some amino acid sequences of the TR9 receptor can be varied without significant effect on the structure or function of the protein. If such differences in sequence are contemplated, it should be remembered that there will be critical areas on the protein which determine activity. Thus, the invention further includes variations of the TR9 receptor which show substantial TR9  
25       receptor activity or which include regions of TR9 receptor protein such as the protein portions discussed below. Such mutants include deletions, insertions, inversions, repeats, and type substitutions. As indicated above, guidance concerning which amino acid changes are likely to be phenotypically silent can be found in Bowie et al., "Deciphering the Message in Protein Sequences: Tolerance to Amino Acid

Substitutions," *Science* 247:1306-1310 (1990).

Thus, the fragment, derivative or analog of the polypeptide of Figures 1A-D (SEQ ID NO:2), or that encoded by the deposited cDNA, may be: (i) one in which one or more of the amino acid residues are substituted with a conserved or non-conserved amino acid residue (preferably a conserved amino acid residue(s), and more preferably at least one but less than ten conserved amino acid residues), and such substituted amino acid residue(s) may or may not be one encoded by the genetic code; or (ii) one in which one or more of the amino acid residues includes a substituent group; or (iii) one in which the mature polypeptide is fused with another compound, such as a compound to increase the half-life of the polypeptide (for example, polyethylene glycol); or (iv) one in which the additional amino acids are fused to the mature polypeptide, such as an IgG Fc fusion region peptide or leader or secretory sequence or a sequence which is employed for purification of the mature polypeptide or a proprotein sequence. Such fragments, derivatives and analogs are deemed to be within the scope of those skilled in the art from the teachings herein.

Of particular interest are substitutions of charged amino acids with another charged amino acid and with neutral or negatively charged amino acids. The latter results in proteins with reduced positive charge to improve the characteristics of the TR9 receptor. The prevention of aggregation is highly desirable. Aggregation of proteins not only results in a loss of activity but can also be problematic when preparing pharmaceutical formulations, because they can be immunogenic. (Pinckard et al., *Clin. Exp. Immunol.* 2:331-340 (1967); Robbins et al., *Diabetes* 36:838-845 (1987); Cleland et al., *Crit. Rev. Therapeutic Drug Carrier Systems* 10:307-377 (1993)).

The replacement of amino acids can also change the selectivity of binding to cell surface receptors. Ostade et al., *Nature* 361:266-268 (1993), describes certain mutations resulting in selective binding of TNF- $\alpha$  to only one of the two known types of TNF receptors. Thus, the TR9 receptor of the present invention may include one or more amino acid substitutions, deletions, or additions, either from



natural mutations or human manipulation.

As indicated, changes are preferably of a minor nature, such as conservative amino acid substitutions that do not significantly affect the folding or activity of the protein (see Table 1).

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**TABLE 1****Conservative Amino Acid Substitutions**

Aromatic	Phenylalanine Tryptophan Tyrosine
Hydrophobic	Leucine Isoleucine Valine
Polar	Glutamine Asparagine
Basic	Arginine Lysine Histidine
Acidic	Aspartic Acid Glutamic Acid
Small	Alanine Serine Threonine Methionine Glycine

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In specific embodiments, the number of substitutions, additions or deletions in the amino acid sequence of Figures 1A-D and/or any of the polypeptide fragments described herein (e.g., the extracellular domain or intracellular domain) is 75, 70, 60, 50, 40, 35, 30, 25, 20, 15, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 or 30-20, 20-15, 20-10, 15-10, 10-1, 5-10, 1-5, 1-3 or 1-2.

Amino acids in the TR9 protein of the present invention that are essential for function can be identified by methods known in the art, such as site-directed

mutagenesis or alanine-scanning mutagenesis (Cunningham and Wells, *Science* 244:1081-1085 (1989)). The latter procedure introduces single alanine mutations at every residue in the molecule. The resulting mutant molecules are then tested for biological activity such as receptor binding or *in vitro* proliferative activity. Sites that are critical for ligand-receptor binding can also be determined by structural analysis such as crystallization, nuclear magnetic resonance or photoaffinity labeling (Smith *et al.*, *J. Mol. Biol.* 224:899-904 (1992) and de Vos *et al.* *Science* 255:306-312 (1992)).

The polypeptides of the present invention are preferably provided in an isolated form. By "isolated polypeptide" is intended a polypeptide removed from its native environment. Thus, a polypeptide produced and/or contained within a recombinant host cell is considered isolated for purposes of the present invention. Also intended as an "isolated polypeptide" are polypeptides that have been purified, partially or substantially, from a recombinant host cell. For example, a recombinantly produced version of the TR9 receptor can be substantially purified by the one-step method described in Smith and Johnson, *Gene* 67:31-40 (1988).

The polypeptides of the present invention include the polypeptide encoded by the deposited cDNA including the leader; the mature polypeptide encoded by the deposited cDNA minus the leader (i.e., the mature protein); a polypeptide comprising amino acids about -40 to about 615 in SEQ ID NO:2; a polypeptide comprising amino acids about -39 to about 615 in SEQ ID NO:2; a polypeptide comprising amino acids about 1 to about 615 in SEQ ID NO:2; a polypeptide comprising the extracellular domain; a polypeptide comprising the four TNFR-like cysteine rich motifs of TR9 (amino acid residues 67 to 211 in Figures 1A-D; amino acid residues 27-171 in SEQ ID NO:2); a polypeptide comprising the transmembrane domain; a polypeptide comprising the intracellular domain; a polypeptide comprising the extracellular and intracellular domains with all or part of the transmembrane domain deleted; a polypeptide comprising the death domain (amino acid residues 429-495 as depicted in Figures 1A-D; amino acid residues 389-455 in SEQ ID NO:2); and/or a polypeptide comprising the TR9 leucine zipper (amino acid residues 497-518 of Figures 1A-D;

amino acid residues 457-478 of SEQ ID NO:2); as well as polypeptides which are at least 80% identical, more preferably at least 90% or 95% identical, still more preferably at least 96%, 97%, 98% or 99% identical to the polypeptides described above, and also include portions of such polypeptides with at least 30 amino acids and more preferably at least 50 amino acids.

By a polypeptide having an amino acid sequence at least, for example, 95% "identical" to a reference amino acid sequence of a TR9 receptor polypeptide is intended that the amino acid sequence of the polypeptide is identical to the reference sequence except that the polypeptide sequence may include up to five amino acid alterations per each 100 amino acids of the reference amino acid of the TR9 receptor. In other words, to obtain a polypeptide having an amino acid sequence at least 95% identical to a reference amino acid sequence, up to 5% of the amino acid residues in the reference sequence may be deleted or substituted with another amino acid, or a number of amino acids up to 5% of the total amino acid residues in the reference sequence may be inserted into the reference sequence. These alterations of the reference sequence may occur at the amino or carboxy terminal positions of the reference amino acid sequence or anywhere between those terminal positions, interspersed either individually among residues in the reference sequence or in one or more contiguous groups within the reference sequence.

As a practical matter, whether any particular polypeptide is at least 90%, 95%, 96%, 97%, 98% or 99% identical to, for instance, the amino acid sequence shown in Figures 1A-D (SEQ ID NO:2), the amino acid sequence encoded by deposited cDNA clone, or fragments thereof, can be determined conventionally using known computer programs such the Bestfit program (Wisconsin Sequence Analysis Package, Version 8 for Unix, Genetics Computer Group, University Research Park, 575 Science Drive, Madison, WI 53711). When using Bestfit or any other sequence alignment program to determine whether a particular sequence is, for instance, 95% identical to a reference sequence according to the present invention, the parameters are set, of course, such that the percentage of identity is calculated over the full length of

the reference amino acid sequence and that gaps in homology of up to 5% of the total number of amino acid residues in the reference sequence are allowed.

In a specific embodiment, the identity between a reference (query) sequence (a sequence of the present invention) and a subject sequence, also referred to as a global sequence alignment, is determined using the FASTDB computer program based on the algorithm of Brutlag et al. (Comp. App. Biosci. 6:237-245 (1990)). Preferred parameters used in a FASTDB amino acid alignment are: Matrix=PAM 0, k-tuple=2, Mismatch Penalty=1, Joining Penalty=20, Randomization Group Length=0, Cutoff Score=1, Window Size=sequence length, Gap Penalty=5, Gap Size Penalty=0.05, Window Size=500 or the length of the subject amino acid sequence, whichever is shorter. According to this embodiment, if the subject sequence is shorter than the query sequence due to N- or C-terminal deletions, not because of internal deletions, a manual correction is made to the results to take into consideration the fact that the FASTDB program does not account for N- and C-terminal truncations of the subject sequence when calculating global percent identity. For subject sequences truncated at the N- and C-termini, relative to the query sequence, the percent identity is corrected by calculating the number of residues of the query sequence that are N- and C-terminal of the subject sequence, which are not matched/aligned with a corresponding subject residue, as a percent of the total bases of the query sequence. A determination of whether a residue is matched/aligned is determined by results of the FASTDB sequence alignment. This percentage is then subtracted from the percent identity, calculated by the above FASTDB program using the specified parameters, to arrive at a final percent identity score. This final percent identity score is what is used for the purposes of this embodiment. Only residues to the N- and C-termini of the subject sequence, which are not matched/aligned with the query sequence, are considered for the purposes of manually adjusting the percent identity score. That is, only query residue positions outside the farthest N- and C-terminal residues of the subject sequence. For example, a 90 amino acid residue subject sequence is aligned with a 100 residue query sequence to determine percent identity. The deletion occurs at the N-

terminus of the subject sequence and therefore, the FASTDB alignment does not show a matching/alignment of the first 10 residues at the N-terminus. The 10 unpaired residues represent 10% of the sequence (number of residues at the N- and C- termini not matched/total number of residues in the query sequence) so 10% is subtracted from the percent identity score calculated by the FASTDB program. If the remaining 90 residues were perfectly matched the final percent identity would be 90%. In another example, a 90 residue subject sequence is compared with a 100 residue query sequence. This time the deletions are internal deletions so there are no residues at the N- or C-termini of the subject sequence which are not matched/aligned with the query. In this case the percent identity calculated by FASTDB is not manually corrected. Once again, only residue positions outside the N- and C-terminal ends of the subject sequence, as displayed in the FASTDB alignment, which are not matched/aligned with the query sequence are manually corrected for. No other manual corrections are made for the purposes of this embodiment.

The polypeptides of the present invention have uses which include, but are not limited to, molecular weight marker on SDS-PAGE gels or on molecular sieve gel filtration columns using methods well known to those of skill in the art.

For many proteins, including the extracellular domain of a membrane associated protein or the mature form(s) of a secreted protein, it is known in the art that one or more amino acids may be deleted from the N-terminus or C-terminus without substantial loss of biological function. However, even if deletion of one or more amino acids from the N-terminus or C-terminus of a protein results in modification or loss of one or more biological functions of the protein, other TR9 functional activities may still be retained. For example, in many instances, the ability of the shortened protein to induce and/or bind to antibodies which recognize TR9 (preferably antibodies that bind specifically to TR9) will be retained irrespective of the size or location of the deletion. Whether a particular polypeptide lacking N-terminal and/or C-terminal residues of a complete protein retains such immunologic activities

can readily be determined by routine methods described herein and otherwise known in the art.

In one embodiment, the present invention further provides polypeptides having one or more residues deleted from the amino terminus of the amino acid sequence of the TR9 polypeptide depicted in Figures 1A-D (SEQ ID NO:2) or encoded by the cDNA of the deposited clone. Particularly, in one embodiment, N-terminal deletions of the TR9 polypeptide can be described by the general formula m to 615, where m is a number from -39 to 614 corresponding to the position of amino acid identified in SEQ ID NO:2 and preferably, corresponds to one of the N-terminal amino acid residues identified in the N-terminal deletions specified herein. In specific embodiments, N-terminal deletions of the TR9 polypeptide of the invention comprise, or alternatively consist of, amino acid residues: Q-2 to L-615; P-3 to L-615; E-4 to L-615; Q-5 to L-615; K-6 to L-615; A-7 to L-615; S-8 to L-615; N-9 to L-615; L-10 to L-615; I-11 to L-615; G-12 to L-615; T-13 to L-615; Y-14 to L-615; R-15 to L-615; H-16 to L-615; V-17 to L-615; D-18 to L-615; R-19 to L-615; A-20 to L-615; T-21 to L-615; G-22 to L-615; Q-23 to L-615; V-24 to L-615; L-25 to L-615; T-26 to L-615; C-27 to L-615; D-28 to L-615; K-29 to L-615; C-30 to L-615; P-31 to L-615; A-32 to L-615; G-33 to L-615; T-34 to L-615; Y-35 to L-615; V-36 to L-615; S-37 to L-615; E-38 to L-615; H-39 to L-615; C-40 to L-615; T-41 to L-615; N-42 to L-615; T-43 to L-615; S-44 to L-615; L-45 to L-615; R-46 to L-615; V-47 to L-615; C-48 to L-615; S-49 to L-615; S-50 to L-615; C-51 to L-615; P-52 to L-615; V-53 to L-615; G-54 to L-615; T-55 to L-615; F-56 to L-615; T-57 to L-615; R-58 to L-615; H-59 to L-615; E-60 to L-615; N-61 to L-615; G-62 to L-615; I-63 to L-615; E-64 to L-615; K-65 to L-615; C-66 to L-615; H-67 to L-615; D-68 to L-615; C-69 to L-615; S-70 to L-615; Q-71 to L-615; P-72 to L-615; C-73 to L-615; P-74 to L-615; W-75 to L-615; P-76 to L-615; M-77 to L-615; I-78 to L-615; E-79 to L-615; K-80 to L-615; L-81 to L-615; P-82 to L-615; C-83 to L-615; A-84 to L-615; A-85 to L-615; L-86 to L-615; T-87 to L-615; D-88 to L-615; R-89 to L-615; E-90 to L-615; C-91 to L-615; T-92 to L-615; C-93 to L-615; P-94 to L-615; P-95 to L-615; G-96 to L-615; M-97 to L-615;

F-98 to L-615; Q-99 to L-615; S-100 to L-615; N-101 to L-615; A-102 to L-615; T-103 to L-615; C-104 to L-615; A-105 to L-615; P-106 to L-615; H-107 to L-615; T-108 to L-615; V-109 to L-615; C-110 to L-615; P-111 to L-615; V-112 to L-615; G-113 to L-615; W-114 to L-615; G-115 to L-615; V-116 to L-615; R-117 to L-615; K-118 to L-615; K-119 to L-615; G-120 to L-615; T-121 to L-615; E-122 to L-615; T-123 to L-615; E-124 to L-615; D-125 to L-615; V-126 to L-615; R-127 to L-615; C-128 to L-615; K-129 to L-615; Q-130 to L-615; C-131 to L-615; A-132 to L-615; R-133 to L-615; G-134 to L-615; T-135 to L-615; F-136 to L-615; S-137 to L-615; D-138 to L-615; V-139 to L-615; P-140 to L-615; S-141 to L-615; S-142 to L-615; V-143 to L-615; M-144 to L-615; K-145 to L-615; C-146 to L-615; K-147 to L-615; A-148 to L-615; Y-149 to L-615; T-150 to L-615; D-151 to L-615; C-152 to L-615; L-153 to L-615; S-154 to L-615; Q-155 to L-615; N-156 to L-615; L-157 to L-615; V-158 to L-615; V-159 to L-615; I-160 to L-615; K-161 to L-615; P-162 to L-615; G-163 to L-615; T-164 to L-615; K-165 to L-615; E-166 to L-615; T-167 to L-615; D-168 to L-615; N-169 to L-615; V-170 to L-615; C-171 to L-615; G-172 to L-615; T-173 to L-615; L-174 to L-615; P-175 to L-615; S-176 to L-615; F-177 to L-615; S-178 to L-615; S-179 to L-615; S-180 to L-615; T-181 to L-615; S-182 to L-615; P-183 to L-615; S-184 to L-615; P-185 to L-615; G-186 to L-615; T-187 to L-615; A-188 to L-615; I-189 to L-615; F-190 to L-615; P-191 to L-615; R-192 to L-615; P-193 to L-615; E-194 to L-615; H-195 to L-615; M-196 to L-615; E-197 to L-615; T-198 to L-615; H-199 to L-615; E-200 to L-615; V-201 to L-615; P-202 to L-615; S-203 to L-615; S-204 to L-615; T-205 to L-615; Y-206 to L-615; V-207 to L-615; P-208 to L-615; K-209 to L-615; G-210 to L-615; M-211 to L-615; N-212 to L-615; S-213 to L-615; T-214 to L-615; E-215 to L-615; S-216 to L-615; N-217 to L-615; S-218 to L-615; S-219 to L-615; A-220 to L-615; S-221 to L-615; V-222 to L-615; R-223 to L-615; P-224 to L-615; K-225 to L-615; V-226 to L-615; L-227 to L-615; S-228 to L-615; S-229 to L-615; I-230 to L-615; Q-231 to L-615; E-232 to L-615; G-233 to L-615; T-234 to L-615; V-235 to L-615; P-236 to L-615; D-237 to L-615; N-238 to L-615; T-239 to L-615; S-240 to L-615; S-241 to L-615; A-242 to L-615; R-

243 to L-615; G-244 to L-615; K-245 to L-615; E-246 to L-615; D-247 to L-615; V-248 to L-615; N-249 to L-615; K-250 to L-615; T-251 to L-615; L-252 to L-615; P-253 to L-615; N-254 to L-615; L-255 to L-615; Q-256 to L-615; V-257 to L-615; V-258 to L-615; N-259 to L-615; H-260 to L-615; Q-261 to L-615; Q-262 to L-615; G-263 to L-615; P-264 to L-615; H-265 to L-615; H-266 to L-615; R-267 to L-615; H-268 to L-615; I-269 to L-615; L-270 to L-615; K-271 to L-615; L-272 to L-615; L-273 to L-615; P-274 to L-615; S-275 to L-615; M-276 to L-615; E-277 to L-615; A-278 to L-615; T-279 to L-615; G-280 to L-615; G-281 to L-615; E-282 to L-615; K-283 to L-615; S-284 to L-615; S-285 to L-615; T-286 to L-615; P-287 to L-615; I-288 to L-615; K-289 to L-615; G-290 to L-615; P-291 to L-615; K-292 to L-615; R-293 to L-615; G-294 to L-615; H-295 to L-615; P-296 to L-615; R-297 to L-615; Q-298 to L-615; N-299 to L-615; L-300 to L-615; H-301 to L-615; K-302 to L-615; H-303 to L-615; F-304 to L-615; D-305 to L-615; I-306 to L-615; N-307 to L-615; E-308 to L-615; H-309 to L-615; L-310 to L-615; P-311 to L-615; W-312 to L-615; M-313 to L-615; I-314 to L-615; V-315 to L-615; L-316 to L-615; F-317 to L-615; L-318 to L-615; L-319 to L-615; L-320 to L-615; V-321 to L-615; L-322 to L-615; V-323 to L-615; V-324 to L-615; I-325 to L-615; V-326 to L-615; V-327 to L-615; C-328 to L-615; S-329 to L-615; I-330 to L-615; R-331 to L-615; K-332 to L-615; S-333 to L-615; S-334 to L-615; R-335 to L-615; T-336 to L-615; L-337 to L-615; K-338 to L-615; K-339 to L-615; G-340 to L-615; P-341 to L-615; R-342 to L-615; Q-343 to L-615; D-344 to L-615; P-345 to L-615; S-346 to L-615; A-347 to L-615; I-348 to L-615; V-349 to L-615; E-350 to L-615; K-351 to L-615; A-352 to L-615; G-353 to L-615; L-354 to L-615; K-355 to L-615; K-356 to L-615; S-357 to L-615; M-358 to L-615; T-359 to L-615; P-360 to L-615; T-361 to L-615; Q-362 to L-615; N-363 to L-615; R-364 to L-615; E-365 to L-615; K-366 to L-615; W-367 to L-615; I-368 to L-615; Y-369 to L-615; Y-370 to L-615; C-371 to L-615; N-372 to L-615; G-373 to L-615; H-374 to L-615; G-375 to L-615; I-376 to L-615; D-377 to L-615; I-378 to L-615; L-379 to L-615; K-380 to L-615; L-381 to L-615; V-382 to L-615; A-383 to L-615; A-384 to L-615; Q-385 to L-615; V-386 to L-615; G-387 to L-615; S-388 to L-



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In another embodiment, N-terminal deletions of the TR9 polypeptide can be described by the general formula m to 310 where m is a number from -40 to 309 corresponding to the amino acid sequence identified in SEQ ID NO:2. In specific embodiments, N terminal deletions of the TR9 of the invention comprise, or alternatively, consist of, amino acid residues: Q-2 to L-310; P-3 to L-310; E-4 to L-310; Q-5 to L-310; K-6 to L-310; A-7 to L-310; S-8 to L-310; N-9 to L-310; L-10 to L-310; I-11 to L-310; G-12 to L-310; T-13 to L-310; Y-14 to L-310; R-15 to L-310; H-16 to L-310; V-17 to L-310; D-18 to L-310; R-19 to L-310; A-20 to L-310; T-21 to L-310; G-22 to L-310; Q-23 to L-310; V-24 to L-310; L-25 to L-310; T-26 to L-310; C-27 to L-310; D-28 to L-310; K-29 to L-310; C-30 to L-310; P-31 to L-310; A-32 to L-310; G-33 to L-310; T-34 to L-310; Y-35 to L-310; V-36 to L-310; S-37 to L-310; E-38 to L-310; H-39 to L-310; C-40 to L-310; T-41 to L-310; N-42 to L-310; T-43 to

L-310; S-44 to L-310; L-45 to L-310; R-46 to L-310; V-47 to L-310; C-48 to L-310;  
S-49 to L-310; S-50 to L-310; C-51 to L-310; P-52 to L-310; V-53 to L-310; G-54 to  
L-310; T-55 to L-310; F-56 to L-310; T-57 to L-310; R-58 to L-310; H-59 to L-310;  
E-60 to L-310; N-61 to L-310; G-62 to L-310; I-63 to L-310; E-64 to L-310; K-65 to  
5 L-310; C-66 to L-310; H-67 to L-310; D-68 to L-310; C-69 to L-310; S-70 to L-310;  
Q-71 to L-310; P-72 to L-310; C-73 to L-310; P-74 to L-310; W-75 to L-310; P-76 to  
L-310; M-77 to L-310; I-78 to L-310; E-79 to L-310; K-80 to L-310; L-81 to L-310;  
P-82 to L-310; C-83 to L-310; A-84 to L-310; A-85 to L-310; L-86 to L-310; T-87 to  
L-310; D-88 to L-310; R-89 to L-310; E-90 to L-310; C-91 to L-310; T-92 to L-310;  
10 C-93 to L-310; P-94 to L-310; P-95 to L-310; G-96 to L-310; M-97 to L-310; F-98 to  
L-310; Q-99 to L-310; S-100 to L-310; N-101 to L-310; A-102 to L-310; T-103 to L-  
310; C-104 to L-310; A-105 to L-310; P-106 to L-310; H-107 to L-310; T-108 to L-  
310; V-109 to L-310; C-110 to L-310; P-111 to L-310; V-112 to L-310; G-113 to L-  
310; W-114 to L-310; G-115 to L-310; V-116 to L-310; R-117 to L-310; K-118 to L-  
15 310; K-119 to L-310; G-120 to L-310; T-121 to L-310; E-122 to L-310; T-123 to L-  
310; E-124 to L-310; D-125 to L-310; V-126 to L-310; R-127 to L-310; C-128 to L-  
310; K-129 to L-310; Q-130 to L-310; C-131 to L-310; A-132 to L-310; R-133 to L-  
310; G-134 to L-310; T-135 to L-310; F-136 to L-310; S-137 to L-310; D-138 to L-  
310; V-139 to L-310; P-140 to L-310; S-141 to L-310; S-142 to L-310; V-143 to L-  
20 310; M-144 to L-310; K-145 to L-310; C-146 to L-310; K-147 to L-310; A-148 to L-  
310; Y-149 to L-310; T-150 to L-310; D-151 to L-310; C-152 to L-310; L-153 to L-  
310; S-154 to L-310; Q-155 to L-310; N-156 to L-310; L-157 to L-310; V-158 to L-  
310; V-159 to L-310; I-160 to L-310; K-161 to L-310; P-162 to L-310; G-163 to L-  
310; T-164 to L-310; K-165 to L-310; E-166 to L-310; T-167 to L-310; D-168 to L-  
25 310; N-169 to L-310; V-170 to L-310; C-171 to L-310; G-172 to L-310; T-173 to L-  
310; L-174 to L-310; P-175 to L-310; S-176 to L-310; F-177 to L-310; S-178 to L-  
310; S-179 to L-310; S-180 to L-310; T-181 to L-310; S-182 to L-310; P-183 to L-  
310; S-184 to L-310; P-185 to L-310; G-186 to L-310; T-187 to L-310; A-188 to L-  
310; I-189 to L-310; F-190 to L-310; P-191 to L-310; R-192 to L-310; P-193 to L-

310; E-194 to L-310; H-195 to L-310; M-196 to L-310; E-197 to L-310; T-198 to L-310; H-199 to L-310; E-200 to L-310; V-201 to L-310; P-202 to L-310; S-203 to L-310; S-204 to L-310; T-205 to L-310; Y-206 to L-310; V-207 to L-310; P-208 to L-310; K-209 to L-310; G-210 to L-310; M-211 to L-310; N-212 to L-310; S-213 to L-310; T-214 to L-310; E-215 to L-310; S-216 to L-310; N-217 to L-310; S-218 to L-310; S-219 to L-310; A-220 to L-310; S-221 to L-310; V-222 to L-310; R-223 to L-310; P-224 to L-310; K-225 to L-310; V-226 to L-310; L-227 to L-310; S-228 to L-310; S-229 to L-310; I-230 to L-310; Q-231 to L-310; E-232 to L-310; G-233 to L-310; T-234 to L-310; V-235 to L-310; P-236 to L-310; D-237 to L-310; N-238 to L-310; T-239 to L-310; S-240 to L-310; S-241 to L-310; A-242 to L-310; R-243 to L-310; G-244 to L-310; K-245 to L-310; E-246 to L-310; D-247 to L-310; V-248 to L-310; N-249 to L-310; K-250 to L-310; T-251 to L-310; L-252 to L-310; P-253 to L-310; N-254 to L-310; L-255 to L-310; Q-256 to L-310; V-257 to L-310; V-258 to L-310; N-259 to L-310; H-260 to L-310; Q-261 to L-310; Q-262 to L-310; G-263 to L-310; P-264 to L-310; H-265 to L-310; H-266 to L-310; R-267 to L-310; H-268 to L-310; I-269 to L-310; L-270 to L-310; K-271 to L-310; L-272 to L-310; L-273 to L-310; P-274 to L-310; S-275 to L-310; M-276 to L-310; E-277 to L-310; A-278 to L-310; T-279 to L-310; G-280 to L-310; G-281 to L-310; E-282 to L-310; K-283 to L-310; S-284 to L-310; S-285 to L-310; T-286 to L-310; P-287 to L-310; I-288 to L-310; K-289 to L-310; G-290 to L-310; P-291 to L-310; K-292 to L-310; R-293 to L-310; G-294 to L-310; H-295 to L-310; P-296 to L-310; R-297 to L-310; Q-298 to L-310; N-299 to L-310; L-300 to L-310; H-301 to L-310; K-302 to L-310; H-303 to L-310; F-304 to L-310; D-305 to L-310; of SEQ ID NO:2. Polynucleotides encoding these polypeptides are also encompassed by the invention.

Further embodiments of the invention are directed to C-terminal deletions of the TR9 polypeptide described by the general formula 1 to n, where n is a number from 2 to 614 corresponding to the position of amino acid residue identified in SEQ ID NO:2 and preferably, corresponds to one of the C-terminal amino acid residues identified in the C-terminal deletions specified herein. In specific embodiments, C

terminal deletions of the TR9 polypeptide of the invention comprise, or alternatively, consist of, amino acid residues: A-1 to L-614; A-1 to D-613; A-1 to P-612; A-1 to L-611; A-1 to H-610; A-1 to S-609; A-1 to Y-608; A-1 to V-607; A-1 to S-606; A-1 to D-605; A-1 to L-604; A-1 to L-603; A-1 to T-602; A-1 to Q-601; A-1 to S-600; A-1 to A-599; A-1 to E-598; A-1 to Q-597; A-1 to S-596; A-1 to K-595; A-1 to V-594; A-1 to G-593; A-1 to I-592; A-1 to I-591; A-1 to E-590; A-1 to F-589; A-1 to L-588; A-1 to R-587; A-1 to D-586; A-1 to L-585; A-1 to K-584; A-1 to D-583; A-1 to E-582; A-1 to A-581; A-1 to Q-580; A-1 to P-579; A-1 to I-578; A-1 to E-577; A-1 to E-576; A-1 to I-575; A-1 to V-574; A-1 to R-573; A-1 to L-572; A-1 to E-571; A-1 to E-570; A-1 to P-569; A-1 to N-568; A-1 to L-567; A-1 to F-566; A-1 to H-565; A-1 to L-564; A-1 to M-563; A-1 to D-562; A-1 to D-561; A-1 to F-560; A-1 to I-559; A-1 to P-558; A-1 to Q-557; A-1 to L-556; A-1 to D-555; A-1 to C-554; A-1 to P-553; A-1 to D-552; A-1 to L-551; A-1 to R-550; A-1 to V-549; A-1 to Q-548; A-1 to R-547; A-1 to L-546; A-1 to V-545; A-1 to T-544; A-1 to D-543; A-1 to K-542; A-1 to K-541; A-1 to E-540; A-1 to K-539; A-1 to T-538; A-1 to I-537; A-1 to F-536; A-1 to S-535; A-1 to G-534; A-1 to N-533; A-1 to R-532; A-1 to S-531; A-1 to L-530; A-1 to A-529; A-1 to S-528; A-1 to S-527; A-1 to G-526; A-1 to S-525; A-1 to S-524; A-1 to T-523; A-1 to S-522; A-1 to D-521; A-1 to C-520; A-1 to R-519; A-1 to L-518; A-1 to L-517; A-1 to P-516; A-1 to E-515; A-1 to S-514; A-1 to E-513; A-1 to D-512; A-1 to V-511; A-1 to F-510; A-1 to F-509; A-1 to G-508; A-1 to K-507; A-1 to N-506; A-1 to K-505; A-1 to D-504; A-1 to Q-503; A-1 to P-502; A-1 to S-501; A-1 to P-500; A-1 to E-499; A-1 to V-498; A-1 to T-497; A-1 to L-496; A-1 to L-495; A-1 to A-494; A-1 to S-493; A-1 to N-492; A-1 to E-491; A-1 to L-490; A-1 to K-489; A-1 to A-488; A-1 to N-487; A-1 to P-486; A-1 to S-485; A-1 to P-484; A-1 to I-483; A-1 to P-482; A-1 to S-481; A-1 to P-480; A-1 to S-479; A-1 to L-478; A-1 to P-477; A-1 to S-476; A-1 to P-475; A-1 to S-474; A-1 to M-473; A-1 to P-472; A-1 to L-471; A-1 to A-470; A-1 to L-469; A-1 to K-468; A-1 to D-467; A-1 to T-466; A-1 to E-465; A-1 to L-464; A-1 to Q-463; A-1 to T-462; A-1 to T-461; A-1 to D-460; A-1 to E-459; A-1 to M-458; A-1 to L-457; A-1 to G-456; A-1 to R-455;

A-1 to I-454; A-1 to K-453; A-1 to E-452; A-1 to V-451; A-1 to V-450; A-1 to D-449; A-1 to N-448; A-1 to R-447; A-1 to R-446; A-1 to H-445; A-1 to Q-444; A-1 to R-443; A-1 to L-442; A-1 to A-441; A-1 to S-440; A-1 to I-439; A-1 to L-438; A-1 to Q-437; A-1 to A-436; A-1 to L-435; A-1 to S-434; A-1 to A-433; A-1 to E-432;  
5 A-1 to P-431; A-1 to G-430; A-1 to R-429; A-1 to I-428; A-1 to T-427; A-1 to W-426; A-1 to H-425; A-1 to Q-424; A-1 to L-423; A-1 to A-422; A-1 to A-421; A-1 to Y-420; A-1 to A-419; A-1 to R-418; A-1 to E-417; A-1 to H-416; A-1 to D-415; A-1 to A-414; A-1 to T-413; A-1 to Y-412; A-1 to G-411; A-1 to N-410; A-1 to S-409; A-1 to F-408; A-1 to A-407; A-1 to A-406; A-1 to V-405; A-1 to E-404; A-1 to R-403; A-1 to E-402; A-1 to S-401; A-1 to A-400; A-1 to N-399; A-1 to C-398; A-1 to L-397; A-1 to F-396; A-1 to Q-395; A-1 to Y-394; A-1 to I-393; A-1 to D-392; A-1 to K-391; A-1 to W-390; A-1 to Q-389; A-1 to S-388; A-1 to G-387; A-1 to V-386; A-1 to Q-385; A-1 to A-384; A-1 to A-383; A-1 to V-382; A-1 to L-381; A-1 to K-380; A-1 to L-379; A-1 to I-378; A-1 to D-377; A-1 to I-376; A-1 to G-375; A-1 to H-374; A-1 to G-373; A-1 to N-372; A-1 to C-371; A-1 to Y-370; A-1 to Y-369; A-1 to I-368; A-1 to W-367; A-1 to K-366; A-1 to E-365; A-1 to R-364; A-1 to N-363; A-1 to Q-362; A-1 to T-361; A-1 to P-360; A-1 to T-359; A-1 to M-358; A-1 to S-357; A-1 to K-356; A-1 to K-355; A-1 to L-354; A-1 to G-353; A-1 to A-352; A-1 to K-351; A-1 to E-350; A-1 to V-349; A-1 to I-348; A-1 to A-347; A-1 to S-346; A-1 to P-345; A-1 to D-344; A-1 to Q-343; A-1 to R-342; A-1 to P-341; A-1 to G-340; A-1 to K-339; A-1 to K-338; A-1 to L-337; A-1 to T-336; A-1 to R-335; A-1 to S-334; A-1 to S-333; A-1 to K-332; A-1 to R-331; A-1 to I-330; A-1 to S-329; A-1 to C-328; A-1 to V-327; A-1 to V-326; A-1 to I-325; A-1 to V-324; A-1 to V-323; A-1 to L-322; A-1 to V-321; A-1 to L-320; A-1 to L-319; A-1 to L-318; A-1 to F-317; A-1 to L-316; A-1 to V-315; A-1 to I-314; A-1 to M-313; A-1 to W-312; A-1 to P-311; A-1 to L-310; A-1 to H-309; A-1 to E-308; A-1 to N-307; A-1 to I-306; A-1 to D-305; A-1 to F-304; A-1 to H-303; A-1 to K-302; A-1 to H-301; A-1 to L-300; A-1 to N-299; A-1 to Q-298; A-1 to R-297; A-1 to P-296; A-1 to H-295; A-1 to G-294; A-1 to R-293; A-1 to K-292; A-1 to P-291; A-1 to G-290; A-1 to K-289; A-1 to I-288; A-

1 to P-287; A-1 to T-286; A-1 to S-285; A-1 to S-284; A-1 to K-283; A-1 to E-282;  
A-1 to G-281; A-1 to G-280; A-1 to T-279; A-1 to A-278; A-1 to E-277; A-1 to M-  
276; A-1 to S-275; A-1 to P-274; A-1 to L-273; A-1 to L-272; A-1 to K-271; A-1 to  
L-270; A-1 to I-269; A-1 to H-268; A-1 to R-267; A-1 to H-266; A-1 to H-265; A-1  
5 to P-264; A-1 to G-263; A-1 to Q-262; A-1 to Q-261; A-1 to H-260; A-1 to N-259;  
A-1 to V-258; A-1 to V-257; A-1 to Q-256; A-1 to L-255; A-1 to N-254; A-1 to P-  
253; A-1 to L-252; A-1 to T-251; A-1 to K-250; A-1 to N-249; A-1 to V-248; A-1 to  
D-247; A-1 to E-246; A-1 to K-245; A-1 to G-244; A-1 to R-243; A-1 to A-242; A-1  
to S-241; A-1 to S-240; A-1 to T-239; A-1 to N-238; A-1 to D-237; A-1 to P-236; A-  
10 1 to V-235; A-1 to T-234; A-1 to G-233; A-1 to E-232; A-1 to Q-231; A-1 to I-230;  
A-1 to S-229; A-1 to S-228; A-1 to L-227; A-1 to V-226; A-1 to K-225; A-1 to P-  
224; A-1 to R-223; A-1 to V-222; A-1 to S-221; A-1 to A-220; A-1 to S-219; A-1 to  
S-218; A-1 to N-217; A-1 to S-216; A-1 to E-215; A-1 to T-214; A-1 to S-213; A-1  
to N-212; A-1 to M-211; A-1 to G-210; A-1 to K-209; A-1 to P-208; A-1 to V-207;  
15 A-1 to Y-206; A-1 to T-205; A-1 to S-204; A-1 to S-203; A-1 to P-202; A-1 to V-  
201; A-1 to E-200; A-1 to H-199; A-1 to T-198; A-1 to E-197; A-1 to M-196; A-1 to  
H-195; A-1 to E-194; A-1 to P-193; A-1 to R-192; A-1 to P-191; A-1 to F-190; A-1  
to I-189; A-1 to A-188; A-1 to T-187; A-1 to G-186; A-1 to P-185; A-1 to S-184; A-  
1 to P-183; A-1 to S-182; A-1 to T-181; A-1 to S-180; A-1 to S-179; A-1 to S-178;  
20 A-1 to F-177; A-1 to S-176; A-1 to P-175; A-1 to L-174; A-1 to T-173; A-1 to G-  
172; A-1 to C-171; A-1 to V-170; A-1 to N-169; A-1 to D-168; A-1 to T-167; A-1 to  
E-166; A-1 to K-165; A-1 to T-164; A-1 to G-163; A-1 to P-162; A-1 to K-161; A-1  
to I-160; A-1 to V-159; A-1 to V-158; A-1 to L-157; A-1 to N-156; A-1 to Q-155; A-  
1 to S-154; A-1 to L-153; A-1 to C-152; A-1 to D-151; A-1 to T-150; A-1 to Y-149;  
25 A-1 to A-148; A-1 to K-147; A-1 to C-146; A-1 to K-145; A-1 to M-144; A-1 to V-  
143; A-1 to S-142; A-1 to S-141; A-1 to P-140; A-1 to V-139; A-1 to D-138; A-1 to  
S-137; A-1 to F-136; A-1 to T-135; A-1 to G-134; A-1 to R-133; A-1 to A-132; A-1  
to C-131; A-1 to Q-130; A-1 to K-129; A-1 to C-128; A-1 to R-127; A-1 to V-126;  
A-1 to D-125; A-1 to E-124; A-1 to T-123; A-1 to E-122; A-1 to T-121; A-1 to G-

120; A-1 to K-119; A-1 to K-118; A-1 to R-117; A-1 to V-116; A-1 to G-115; A-1 to W-114; A-1 to G-113; A-1 to V-112; A-1 to P-111; A-1 to C-110; A-1 to V-109; A-1 to T-108; A-1 to H-107; A-1 to P-106; A-1 to A-105; A-1 to C-104; A-1 to T-103; A-1 to A-102; A-1 to N-101; A-1 to S-100; A-1 to Q-99; A-1 to F-98; A-1 to M-97; 5 A-1 to G-96; A-1 to P-95; A-1 to P-94; A-1 to C-93; A-1 to T-92; A-1 to C-91; A-1 to -90; A-1 to R-89; A-1 to D-88; A-1 to T-87; A-1 to L-86; A-1 to A-85; A-1 to A-84; A-1 to C-83; A-1 to P-82; A-1 to L-81; A-1 to K-80; A-1 to E-79; A-1 to I-78; A-1 to M-77; A-1 to P-76; A-1 to W-75; A-1 to P-74; A-1 to C-73; A-1 to P-72; A-1 to Q-71; A-1 to S-70; A-1 to C-69; A-1 to D-68; A-1 to H-67; A-1 to C-66; A-1 to K-10 65; A-1 to E-64; A-1 to I-63; A-1 to G-62; A-1 to N-61; A-1 to E-60; A-1 to H-59; A-1 to R-58; A-1 to T-57; A-1 to F-56; A-1 to T-55; A-1 to G-54; A-1 to V-53; A-1 to P-52; A-1 to C-51; A-1 to S-50; A-1 to S-49; A-1 to C-48; A-1 to V-47; A-1 to R-46; A-1 to L-45; A-1 to S-44; A-1 to T-43; A-1 to N-42; A-1 to T-41; A-1 to C-40; A-1 to H-39; A-1 to E-38; A-1 to S-37; A-1 to V-36; A-1 to Y-35; A-1 to T-34; A-1 15 to G-33; A-1 to A-32; A-1 to P-31; A-1 to C-30; A-1 to K-29; A-1 to D-28; A-1 to C-27; A-1 to T-26; A-1 to L-25; A-1 to V-24; A-1 to Q-23; A-1 to G-22; A-1 to T-21; A-1 to A-20; A-1 to R-19; A-1 to D-18; A-1 to V-17; A-1 to H-16; A-1 to R-15; A-1 to Y-14; A-1 to T-13; A-1 to G-12; A-1 to I-11; A-1 to L-10; A-1 to N-9; A-1 to S-8; A-1 to A-7; A-1 to K-6; of SEQ ID NO:2. Polynucleotides encoding these 20 polypeptides are also encompassed by the invention.

Further embodiments of the invention are directed to polypeptide fragments comprising, or alternatively, consisting of, amino acids described by the general formula m to n, where m and n correspond to any one of the amino acid residues specified above for these symbols, respectively. Polynucleotides encoding these 25 polypeptides are also encompassed by the invention.

Polypeptide fragments of the present invention include polypeptides comprising an amino acid sequence contained in SEQ ID NO:2, encoded by the cDNA contained in the deposited clone, or encoded by nucleic acids which hybridize (e.g., under stringent hybridization conditions) to the nucleotide sequence contained in the



deposited clone, or shown in Figures 1A-D (SEQ ID NO:1) or the complementary strand thereto. Protein fragments may be "free-standing," or comprised within a larger polypeptide of which the fragment forms a part or region, most preferably as a single continuous region. Representative examples of polypeptide fragments of the invention, include, for example, fragments that comprise or alternatively, consist of, from about amino acid residues -40 to 1, 1 to 20, 21 to 40, 41 to 60, 61 to 83, 84 to 100, 101 to 120, 121 to 140, 141 to 160, 160-167, 161 to 180, 181 to 200, 201 to 220, 221 to 240, 241 to 260, 261 to 280, 281 to 310, 311 to 350, 351 to 400, 401 to 450, 451 to 500, 551 to 600, or 601 to the end of the coding region of SEQ ID NO:2. Moreover, polypeptide fragments can be at least about 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, or 150 amino acids in length. In this context "about" includes the particularly recited ranges, larger or smaller by several (5, 4, 3, 2, or 1) amino acids, at either extreme or at both extremes.

Among the especially preferred fragments of the invention are fragments characterized by structural or functional attributes of TR9. Such fragments include amino acid residues that comprise alpha-helix and alpha-helix forming regions ("alpha-regions"), beta-sheet and beta-sheet-forming regions ("beta-regions"), turn and turn-forming regions ("turn-regions"), coil and coil-forming regions ("coil-regions"), hydrophilic regions, hydrophobic regions, alpha amphipathic regions, beta amphipathic regions, surface forming regions, and high antigenic index regions (i.e., regions of polypeptides consisting of amino acid residues having an antigenic index of or equal to greater than 1.5, as identified using the default parameters of the Jameson-Wolf program) of TR9. Certain preferred regions are those disclosed in Figure 3 and include, but are not limited to, regions of the aforementioned types identified by analysis of the amino acid sequence depicted in Figures 1A-D, such preferred regions include; Garnier-Robson predicted alpha-regions, beta-regions, turn-regions, and coil-regions; Chou-Fasman predicted alpha-regions, beta-regions, turn-regions, and coil-regions; Kyte-Doolittle predicted hydrophilic and hydrophobic regions; Eisenberg alpha and beta amphipathic regions; Emini surface-forming regions; and Jameson-Wolf

high antigenic index regions, as predicted using the default parameters of these computer programs. Polynucleotides encoding these polypeptides are also encompassed by the invention.

5 In specific embodiments, polypeptide fragments of the invention comprise, or alternatively, consist of, amino acid residues: 40 to 48, 40 to 51, 51 to 66, 66 to 73, 73 to 83, 83 to 104, 104 to 110, 110 to 128, 128 to 146, 146 to 152, 40 to 152, and/or 28 to 171 in SEQ ID NO:2.

10 In other embodiments, the fragments or polypeptides of the invention (i.e., those described herein) are not larger than 610, 600, 580, 570, 550, 525, 500, 475, 450, 400, 425, 390, 380, 375, 350, 336, 334, 331, 305, 300, 295, 290, 285, 280, 275, 260, 250, 225, 200, 185, 175, 170, 165, 160, 155, 150, 145, 140, 135, 130, 125, 120, 115, 110, 105, 100, 90, 80, 75, 60, 50, 40, 30, or 25 amino acid residues in length.

15 In another aspect, the invention provides a peptide or polypeptide comprising an epitope-bearing portion of a polypeptide of the invention. The epitope of this polypeptide portion is an immunogenic or antigenic epitope of a polypeptide described herein. An "immunogenic epitope" is defined as a part of a protein that elicits an antibody response when the whole protein is the immunogen. On the other hand, a region of a protein molecule to which an antibody can bind is defined as an "antigenic epitope." The number of immunogenic epitopes of a protein generally is  
20 less than the number of antigenic epitopes. See, for instance, Geysen et al., *Proc. Natl. Acad. Sci. USA* 81:3998-4002 (1983).

25 As to the selection of peptides or polypeptides bearing an antigenic epitope (i.e., that contain a region of a protein molecule to which an antibody can bind), it is well known in that art that relatively short synthetic peptides that mimic part of a protein sequence are routinely capable of eliciting an antiserum that reacts with the partially mimicked protein. See, for instance, J.G. Sutcliffe et al., "Antibodies That React With Predetermined Sites on Proteins," *Science* 219:660-666 (1983). Peptides capable of eliciting protein-reactive sera are frequently represented in the primary sequence of a protein, can be characterized by a set of simple chemical rules, and are

confined neither to immunodominant regions of intact proteins (i.e., immunogenic epitopes) nor to the amino or carboxyl terminals.

Antigenic epitope-bearing peptides and polypeptides of the invention are therefore useful to raise antibodies, including monoclonal antibodies, that bind specifically to a polypeptide of the invention. See, for instance, Wilson et al., *Cell* 37:767-778 (1984) at 777. Antigenic epitope-bearing peptides and polypeptides of the invention preferably contain a sequence of at least seven, more preferably at least nine and most preferably between at least about 15 to about 30 amino acids contained within the amino acid sequence of a polypeptide of the invention.

Non-limiting examples of antigenic polypeptides or peptides that can be used to generate TR9 receptor-specific antibodies include: a polypeptide comprising amino acid residues from about 4 to about 81 in SEQ ID NO:2, about 116 to about 271 in SEQ ID NO:2, about 283 to about 308 in SEQ ID NO:2, about 336 to about 372 in SEQ ID NO:2, about 393 to about 434 in SEQ ID NO:2, about 445 to about 559 in SEQ ID NO:2, and about 571 to about 588 in SEQ ID NO:2. As indicated above, the inventors have determined that the above polypeptide fragments are antigenic regions of the TR9 receptor protein.

The epitope-bearing peptides and polypeptides of the invention may be produced by any conventional means. R.A. Houghten, "General Method for the Rapid Solid-Phase Synthesis of Large Numbers of Peptides: Specificity of Antigen-Antibody Interaction at the Level of Individual Amino Acids," *Proc. Natl. Acad. Sci. USA* 82:5131-5135 (1985). This "Simultaneous Multiple Peptide Synthesis (SMPS)" process is further described in U.S. Patent No. 4,631,211 to Houghten et al. (1986).

As one of skill in the art will appreciate, TR9 receptor polypeptides of the present invention and the epitope-bearing fragments thereof described above can be combined with parts of the constant domain of immunoglobulins (IgG), resulting in chimeric polypeptides. These fusion proteins facilitate purification and show an increased half-life *in vivo*. This has been shown, e.g., for chimeric proteins consisting of the first two domains of the human CD4-polypeptide and various domains of the

constant regions of the heavy or light chains of mammalian immunoglobulins (EPA 394,827; Traunecker et al., *Nature* 331:84-86 (1988)). Fusion proteins that have a disulfide-linked dimeric structure due to the IgG part can also be more efficient in binding and neutralizing other molecules than the monomeric TR9 protein or protein  
5 fragment alone (Fountoulakis et al., *J. Biochem.* 270:3958-3964 (1995)).

### *Polypeptide Assays*

The present invention also relates to diagnostic assays such as quantitative and diagnostic assays for detecting levels of TR9 receptor protein, or the soluble form  
10 thereof, in cells and tissues, including determination of normal and abnormal levels. Thus, for instance, a diagnostic assay in accordance with the invention for detecting over-expression of TR9, or soluble form thereof, compared to normal control tissue samples may be used to detect the presence of tumors, for example. Assay  
15 techniques that can be used to determine levels of a protein, such as a TR9 protein of the present invention, or a soluble form thereof, in a sample derived from a host are well-known to those of skill in the art. Such assay methods include radioimmunoassays, competitive-binding assays, Western Blot analysis and ELISA assays.

Assaying TR9 protein levels in a biological sample can occur using any art-  
20 known method. By "biological sample" is intended any biological sample obtained from an individual, cell line, tissue culture, or other source which contains TR9 receptor protein or mRNA. Preferred for assaying TR9 protein levels in a biological sample are antibody-based techniques. For example, TR9 protein expression in tissues can be studied with classical immunohistological methods. (Jalkanen et al., *J.  
25 Cell. Biol.* 101:976-985 (1985); Jalkanen et al., *J. Cell. Biol.* 105:3087-3096 (1987)). Other antibody-based methods useful for detecting TR9 receptor gene expression include immunoassays, such as the enzyme linked immunosorbent assay (ELISA) and the radioimmunoassay (RIA).

Suitable labels are known in the art and include enzyme labels, such as, glucose oxidase, and radioisotopes, such as iodine ( $^{125}\text{I}$ ,  $^{127}\text{I}$ ), carbon ( $^{14}\text{C}$ ), sulphur ( $^{35}\text{S}$ ), tritium ( $^3\text{H}$ ), indium ( $^{112}\text{In}$ ), and technetium ( $^{99\text{m}}\text{Tc}$ ), and fluorescent labels, such as fluorescein and rhodamine, and biotin.

5

### *Therapeutics*

The tumor necrosis factor (TNF) family ligands are known to be among the most pleiotropic cytokines, inducing a large number of cellular responses, including cytotoxicity, anti-viral activity, immunoregulatory activities, and the transcriptional regulation of several genes (D.V. Goeddel et al., "Tumor Necrosis Factors: Gene Structure and Biological Activities," *Symp. Quant. Biol.* 51:597- 609 (1986), Cold Spring Harbor; B. Beutler and A. Cerami, *Annu. Rev. Biochem.* 57:505-518 (1988); L.J. Old, *Sci. Am.* 258:59-75 (1988); W. Fiers, *FEBS Lett.* 285:199-224 (1991)). The TNF-family ligands induce such various cellular responses by binding to TNF-family receptors, including the TR9 of the present invention. Cells which express the TR9 polypeptide and are believed to have a potent cellular response to TR9 ligands include fetal liver, PBL, lung, kidney, small intestine, colon, keratinocytes, endothelial cells, and monocyte activated tissue. By "a cellular response to a TNF-family ligand" is intended any genotypic, phenotypic, and/or morphologic change to a cell, cell line, tissue, tissue culture or patient that is induced by a TNF-family ligand. As indicated, such cellular responses include not only normal physiological responses to TNF-family ligands, but also diseases associated with increased apoptosis or the inhibition of apoptosis. Apoptosis-programmed cell death is a physiological mechanism involved in the deletion of peripheral T lymphocytes of the immune system, and its dysregulation can lead to a number of different pathogenic processes (J.C. Ameisen, *AIDS* 8:1197-1213 (1994); P.H. Krammer et al., *Curr. Opin. Immunol.* 6:279-289 (1994)).

25

Diseases associated with increased cell survival, or the inhibition of apoptosis, include cancers (such as follicular lymphomas, carcinomas with p53 mutations, and

hormone-dependent tumors, such as breast cancer, prostate cancer, Kaposi's sarcoma and ovarian cancer); autoimmune disorders (such as systemic lupus erythematosus and immune-related glomerulonephritis rheumatoid arthritis); viral infections (such as herpes viruses, pox viruses and adenoviruses); inflammation; graft vs. host disease; acute graft rejection and chronic graft rejection. Diseases associated with increased apoptosis include AIDS; neurodegenerative disorders (such as Alzheimer's disease, Parkinson's disease, Amyotrophic lateral sclerosis, Retinitis pigmentosa, Cerebellar degeneration); myelodysplastic syndromes (such as aplastic anemia), ischemic injury (such as that caused by myocardial infarction, stroke and reperfusion injury), toxin-induced liver disease (such as that caused by alcohol), septic shock, cachexia and anorexia.

Thus, in one aspect, the present invention is directed to a method for enhancing apoptosis induced by a TNF-family ligand, which involves administering to a cell which expresses the TR9 polypeptide, an effective amount of TR9 ligand, analog or an agonist capable of increasing TR9 mediated signaling. Preferably, TR9 mediated signaling is increased to treat a disease wherein decreased apoptosis or decreased cytokine and adhesion molecule expression is exhibited. Agonists include, but are not limited to, soluble forms of TR9 and antibodies (preferably monoclonal) directed against the TR9 polypeptide.

In a further aspect, the present invention is directed to a method for inhibiting apoptosis induced by a TNF-family ligand, which involves administering to a cell which expresses the TR9 polypeptide an effective amount of an antagonist capable of decreasing TR9 mediated signaling. Preferably, TR9 mediated signaling is decreased to treat a disease wherein increased apoptosis, NFkB expression and/or JNK expression is exhibited. Antagonists include, but are not limited to, soluble forms of TR9 polypeptide and antibodies (preferably monoclonal) directed against the TR9 polypeptide.

By "agonist" is intended naturally occurring and synthetic compounds capable of enhancing or potentiating apoptosis. By "antagonist" is intended naturally

occurring and synthetic compounds capable of inhibiting apoptosis. Whether any candidate "agonist" or "antagonist" of the present invention can enhance or inhibit apoptosis can be determined using art-known TNF-family ligand/receptor cellular response assays, including those described in more detail below.

5           One such screening procedure involves the use of melanophores which are transfected to express the receptor of the present invention. Such a screening technique is described in PCT WO 92/01810, published February 6, 1992. Such an assay may be employed, for example, for screening for a compound which inhibits (or enhances) activation of the receptor polypeptide of the present invention by  
10           contacting the melanophore cells which encode the receptor with both a TNF-family ligand and the candidate antagonist (or agonist). Inhibition or enhancement of the signal generated by the ligand indicates that the compound is an antagonist or agonist of the ligand/receptor signaling pathway:

          Other screening techniques include the use of cells which express the receptor  
15           (for example, transfected CHO cells) in a system which measures extracellular pH changes caused by receptor activation, for example, as described in *Science* 246:181-296 (1989). For example, compounds may be contacted with a cell which expresses the receptor polypeptide of the present invention and a second messenger response, e.g., signal transduction or pH changes, may be measured to determine whether the  
20           potential compound activates or inhibits the receptor.

          Another such screening technique involves introducing RNA encoding the receptor into *Xenopus* oocytes to transiently express the receptor. The receptor oocytes may then be contacted with the receptor ligand and a compound to be screened, followed by detection of inhibition or activation of a calcium signal in the  
25           case of screening for compounds which are thought to inhibit activation of the receptor.

          Another screening technique well known in the art involves expressing in cells a construct wherein the receptor is linked to a phospholipase C or D. Exemplary cells include endothelial cells, smooth muscle cells, embryonic kidney cells, etc. The

screening may be accomplished as hereinabove described by detecting activation of the receptor or inhibition of activation of the receptor from the phospholipase signal.

Another method involves screening for compounds which inhibit activation of the receptor polypeptide of the present invention antagonists by determining inhibition of binding of labeled ligand to cells which have the receptor on the surface thereof. Such a method involves transfecting a eukaryotic cell with DNA encoding the receptor such that the cell expresses the receptor on its surface and contacting the cell with a compound in the presence of a labeled form of a known ligand. The ligand can be labeled, e.g., by radioactivity. The amount of labeled ligand bound to the receptors is measured, e.g., by measuring radioactivity of the receptors. If the compound binds to the receptor as determined by a reduction of labeled ligand which binds to the receptors, the binding of labeled ligand to the receptor is inhibited.

Soluble forms of the polypeptides of the present invention may be utilized in the ligand binding assay described above. These forms of the TR9 receptors are contacted with ligands in the extracellular medium after they are secreted. A determination is then made as to whether the secreted protein will bind to TR9 receptor ligands.

Further screening assays for agonists and antagonists of the present invention are described in Tartaglia et al., *J. Biol. Chem.* 267:4304-4307(1992).

Thus, in a further aspect, a screening method is provided for determining whether a candidate agonist or antagonist is capable of enhancing or inhibiting a cellular response to a TNF-family ligand. The method involves contacting cells which express the TR9 polypeptide with a candidate compound and a TNF-family ligand, assaying a cellular response, and comparing the cellular response to a standard cellular response, the standard being assayed when contact is made with the ligand in absence of the candidate compound, whereby an increased cellular response over the standard indicates that the candidate compound is an agonist of the ligand/receptor signaling pathway and a decreased cellular response compared to the standard indicates that the candidate compound is an antagonist of the ligand/receptor signaling pathway. By



"assaying a cellular response" is intended qualitatively or quantitatively measuring a cellular response to a candidate compound and/or a TNF-family ligand (e.g., determining or estimating an increase or decrease in T cell proliferation or tritiated thymidine labeling). By the invention, a cell expressing the TR9 polypeptide can be contacted with either an endogenous or exogenously administered TNF-family ligand.

Agonist according to the present invention include naturally occurring and synthetic compounds such as, for example, TNF family ligand peptide fragments, transforming growth factor, neurotransmitters (such as glutamate, dopamine, *N*-methyl-D-aspartate), tumor suppressors (p53), cytolytic T cells and antimetabolites. Preferred agonists include chemotherapeutic drugs such as, for example, cisplatin, doxorubicin, bleomycin, cytosine arabinoside, nitrogen mustard, methotrexate and vincristine. Others include ethanol and  $\beta$ -amyloid peptide. (*Science* 267:1457-1458 (1995)). Further preferred agonists include polyclonal and monoclonal antibodies raised against the TR9 polypeptides of the invention, or a fragment thereof. Such agonist antibodies raised against a TNF-family receptor are disclosed in Tartaglia et al., *Proc. Natl. Acad. Sci. USA* 88:9292-9296 (1991); and Tartaglia et al., *J. Biol. Chem.* 267:4304-4307(1992). See, also, PCT Application WO 94/09137.

Antagonists according to the present invention include naturally occurring and synthetic compounds such as, for example, the CD40 ligand, neutral amino acids, zinc, estrogen, androgens, viral genes (such as Adenovirus *E1B*, Baculovirus *p35* and *IAP*, Cowpox virus *crmA*, Epstein-Barr virus *BHRF1*, *LMP-1*, African swine fever virus *LMW5-HL*, and Herpesvirus  $\gamma$ 1 34.5), calpain inhibitors, cysteine protease inhibitors, and tumor promoters (such as PMA, Phenobarbital, and  $\gamma$ -Hexachlorocyclohexane).

In specific embodiments, antagonists according to the present invention are nucleic acids corresponding to the sequences contained in Figures 1A-D, or the complementary strand thereof, and/or to nucleotide sequences contained in the deposited clone. In one embodiment, antisense sequence is generated internally by the organism, in another embodiment, the antisense sequence is separately administered (see, for example, O'Connor, J., *Neurochem.* 56:560 (1991). *Oligodeoxynucleotides as*

*Antisense Inhibitors of Gene Expression*, CRC Press, Boca Raton, FL (1988). Antisense technology can be used to control gene expression through antisense DNA or RNA, or through triple-helix formation. Antisense techniques are discussed for example, in Okano, J., *Neurochem.* 56:560 (1991); *Oligodeoxynucleotides as Antisense*  
5 *Inhibitors of Gene Expression*, CRC Press, Boca Raton, FL (1988). Triple helix formation is discussed in, for instance, Lee et al., *Nucleic Acids Research* 6:3073 (1979); Cooney et al., *Science* 241:456 (1988); and Dervan et al., *Science* 251:1300 (1991). The methods are based on binding of a polynucleotide to a complementary DNA or RNA.

10 For example, the 5' coding portion of a polynucleotide that encodes the mature polypeptide of the present invention may be used to design an antisense RNA polynucleotide of from about 10 to 40 base pairs in length. A DNA polynucleotide is designed to be complementary to a region of the gene involved in transcription thereby preventing transcription and the production of the receptor. The antisense RNA  
15 polypeptide hybridizes to the mRNA *in vivo* and blocks translation of the mRNA molecule into receptor polypeptide. The polynucleotides described herein can also be delivered to cells such that the antisense RNA or DNA may be expressed *in vivo* to inhibit production of the receptor.

In one embodiment, the TR9 antisense nucleic acid of the invention is  
20 produced intracellularly by transcription from an exogenous sequence. For example, a vector or a portion thereof, is transcribed, producing an antisense nucleic acid (RNA) of the invention. Such a vector would contain a sequence encoding the TR9 antisense nucleic acid. Such a vector can remain episomal or become chromosomally integrated, as long as it can be transcribed to produce the desired antisense RNA. Such vectors  
25 can be constructed by recombinant DNA technology methods standard in the art. Vectors can be plasmid, viral, or others known in the art, used for replication and expression in vertebrate cells. Expression of the sequence encoding TR9, or fragments thereof, can be by any promoter known in the art to act in vertebrate, preferably human cells. Such promoters can be inducible or constitutive. Such promoters

include, but are not limited to, the SV40 early promoter region (Bernoist and Chambon, *Nature* 29:304-310 (1981), the promoter contained in the 3' long terminal repeat of Rous sarcoma virus (Yamamoto et al., *Cell* 22:787-797 (1980), the herpes thymidine promoter (Wagner et al., *Proc. Natl. Acad. Sci. U.S.A.* 78:1441-1445 (1981), the regulatory sequences of the metallothionein gene (Brinster et al., *Nature* 296:39-42 (1982)), etc.

The antisense nucleic acids of the invention comprise a sequence complementary to at least a portion of an RNA transcript of a TR9 gene. However, absolute complementarity, although preferred, is not required. A sequence "complementary to at least a portion of an RNA," referred to herein, means a sequence having sufficient complementarity to be able to hybridize with the RNA, forming a stable duplex; in the case of double stranded TR9 antisense nucleic acids, a single strand of the duplex DNA may thus be tested, or triplex formation may be assayed. The ability to hybridize will depend on both the degree of complementarity and the length of the antisense nucleic acid. Generally, the larger the hybridizing nucleic acid, the more base mismatches with a TR9 RNA it may contain and still form a stable duplex (or triplex as the case may be). One skilled in the art can ascertain a tolerable degree of mismatch by use of standard procedures to determine the melting point of the hybridized complex.

Potential antagonists according to the invention also include catalytic RNA, or a ribozyme (See, e.g., PCT International Publication WO 90/11364, published October 4, 1990; Sarver et al, *Science* 247:1222-1225 (1990). While ribozymes that cleave mRNA at site specific recognition sequences can be used to destroy TR9 mRNAs, the use of hammerhead ribozymes is preferred. Hammerhead ribozymes cleave mRNAs at locations dictated by flanking regions that form complementary base pairs with the target mRNA. The sole requirement is that the target mRNA have the following sequence of two bases: 5'-UG-3'. The construction and production of hammerhead ribozymes is well known in the art and is described more fully in Haseloff and Gerlach, *Nature* 334:585-591 (1988). There are numerous potential hammerhead

ribozyme cleavage sites within the nucleotide sequence of TR9 (Figures 1A-D). Preferably, the ribozyme is engineered so that the cleavage recognition site is located near the 5' end of the TR9 mRNA; i.e., to increase efficiency and minimize the intracellular accumulation of non-functional mRNA transcripts. DNA constructs  
5 encoding the ribozyme may be introduced into the cell in the same manner as described above for the introduction of antisense encoding DNA. Since ribozymes, unlike antisense molecules are catalytic, a lower intracellular concentration is required for efficiency.

Further antagonists according to the present invention include soluble forms of  
10 TR9, (e.g., fragments of the TR9 receptor sequence depicted in Figures 1A-D that include the ligand binding domain from the extracellular region of the full length receptor). Such soluble forms of the receptor, which may be naturally occurring or synthetic, antagonize TR9 mediated signaling by competing with the cell surface TR9 for binding to TNF-family ligands. Thus, soluble forms of the receptor that include  
15 the ligand binding domain are novel cytokines capable of inhibiting apoptosis induced by TNF-family ligands. These are preferably expressed as dimers or trimers, since these have been shown to be superior to monomeric forms of soluble receptor as antagonists, e.g., IgGFc-TNF receptor family fusions. Other such cytokines are known in the art and include Fas B (a soluble form of the mouse Fas receptor) that  
20 acts physiologically to limit apoptosis induced by Fas ligand (Hughes and Crispe, *J. Exp. Med.* 182:1395-1401 (1995)).

The experiments set forth in Example 5 and 6, indicate that the TR9 receptor, like other homologous proteins, is a death domain-containing molecule capable of triggering apoptosis, which is important in the regulation of the immune system. In  
25 addition, the experiments set forth below suggest that TR9-induced apoptosis will be blocked by the inhibitors of ICE-like proteases, CrmA and z-VAD-fmk. Importantly, it is also expected that apoptosis induced by TR9 will be blocked by dominant negative versions of FADD (FADD-DN) or FLICE (FLICE-DN/MACHa1C360S), which were previously shown to inhibit death signaling by Fas/APO-1 and TNFR-1.

Thus, inhibitors of ICE-like proteases, FADD-DN and FLICE-DN/MACHa1C360S could also be used as antagonists for TR9 activity.

Antagonists of the present invention also include antibodies specific for TNF-family ligands or the TR9 polypeptides of the invention. The term "antibody" (Ab) or "monoclonal antibody" (mAb) as used herein is meant to include intact molecules as well as fragments thereof (such as, e.g., Fab and F(ab')<sub>2</sub> fragments) which are capable of binding an antigen. Fab and F(ab')<sub>2</sub> fragments lack the Fc fragment of intact antibody, clear more rapidly from the circulation, and may have less non-specific tissue binding of an intact antibody (Wahl et al., *J. Nucl. Med.* 24:316-325 (1983)).

Antibodies according to the present invention may be prepared by any of a variety of standard methods using TR9 immunogens of the present invention. As indicated, such TR9 immunogens include the full length TR9 polypeptide depicted in Figures 1A-D (SEQ ID NO:2) (which may or may not include the leader sequence) and TR9 polypeptide fragments comprising, for example, the ligand binding domain, extracellular domain, transmembrane domain, intracellular domain, death domain, incomplete death domain, or any combination thereof.

Polyclonal and monoclonal antibody agonists or antagonists according to the present invention can be raised according to the methods disclosed in Tartaglia and Goeddel, *J. Biol. Chem.* 267(7):4304-4307(1992)); Tartaglia et al., *Cell* 73:213-216 (1993)), and PCT Application WO 94/09137 and are preferably specific to (i.e., bind uniquely to polypeptides of the invention having the amino acid sequence of SEQ ID NO:2. The term "antibody" (Ab) or "monoclonal antibody" (mAb) as used herein is meant to include intact molecules as well as fragments thereof (such as, for example, Fab and F(ab') fragments) which are capable of binding an antigen. Fab, Fab' and F(ab') fragments lack the Fc fragment intact antibody, clear more rapidly from the circulation, and may have less non-specific tissue binding of an intact antibody (Wahl et al., *J. Nucl. Med.*, 24:316-325 (1983)).

In a preferred method, antibodies according to the present invention are mAbs. Such mAbs can be prepared using hybridoma technology (Kohler and Millstein,

*Nature* 256:495-497 (1975) and U.S. Patent No. 4,376,110; Harlow et al., *Antibodies: A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, 1988; *Monoclonal Antibodies and Hybridomas: A New Dimension in Biological Analyses*, Plenum Press, New York, NY, 1980; Campbell, "Monoclonal Antibody Technology," In: *Laboratory Techniques in Biochemistry and Molecular Biology*, Volume 13 (Burdon et al., eds.), Elsevier, Amsterdam (1984)).

Proteins and other compounds which bind the TR9 domains are also candidate agonists and antagonists according to the present invention. Such binding compounds can be "captured" using the yeast two-hybrid system (Fields and Song, *Nature* 340:245-246 (1989)). A modified version of the yeast two- hybrid system has been described by Roger Brent and his colleagues (Gyuris, *Cell* 75:791-803 (1993); Zervos et al., *Cell* 72:223-232 (1993)). Preferably, the yeast two-hybrid system is used according to the present invention to capture compounds which bind to the ligand binding domain, extracellular, intracellular, transmembrane, and death domain of the TR9. Such compounds are good candidate agonists and antagonists of the present invention.

Using the two-hybrid assay described above, the intracellular domain of the TR9 receptor, or a portion thereof, may be used to identify cellular proteins which interact with the receptor *in vivo*. Such an assay may also be used to identify ligands with potential agonistic or antagonistic activity of TR9 receptor function. This screening assay has previously been used to identify protein which interact with the cytoplasmic domain of the murine TNF-RII and led to the identification of two receptor associated proteins. Rothe et al., *Cell* 78:681 (1994). Such proteins and amino acid sequences which bind to the cytoplasmic domain of the TR9 receptors are good candidate agonist and antagonist of the present invention.

Other screening techniques include the use of cells which express the polypeptide of the present invention (for example, transfected CHO cells) in a system which measures extracellular pH changes caused by receptor activation, for example, as described in *Science*, 246:181-296 (1989). In another example, potential agonists or

antagonists may be contacted with a cell which expresses the polypeptide of the present invention and a second messenger response, e.g., signal transduction may be measured to determine whether the potential antagonist or agonist is effective.

By a "TNF-family ligand" is intended naturally occurring, recombinant, and synthetic ligands that are capable of binding to a member of the TNF receptor family and inducing the ligand/receptor signaling pathway. Members of the TNF ligand family include, but are not limited to TR9 ligands including TRAIL, TNF- $\alpha$ , lymphotoxin- $\alpha$  (LT- $\alpha$ , also known as TNF- $\beta$ ), LT- $\beta$  (found in complex heterotrimer LT- $\alpha$ 2- $\beta$ ), FasL, CD40, CD27, CD30, 4-1BB, OX40, and nerve growth factor (NGF).

Representative therapeutic applications of the present invention are discussed in more detail below. The state of immunodeficiency that defines AIDS is secondary to a decrease in the number and function of CD4<sup>+</sup> T-lymphocytes. Recent reports estimate the daily loss of CD4<sup>+</sup> T cells to be between  $3.5 \times 10^7$  and  $2 \times 10^9$  cells (Wei et al., *Nature* 373:117-122 (1995)). One cause of CD4<sup>+</sup> T cell depletion in the setting of HIV infection is believed to be HIV-induced apoptosis. Indeed, HIV-induced apoptotic cell death has been demonstrated not only *in vitro* but also, more importantly, in infected individuals (Ameisen, J.C., *AIDS* 8:1197-1213 (1994); Finkel and Banda, *Curr. Opin. Immunol.* 6:605-615(1995); Muro-Cacho et al., *J. Immunol.* 154:5555-5566 (1995)). Furthermore, apoptosis and CD4<sup>+</sup> T-lymphocyte depletion is tightly correlated in different animal models of AIDS (Brunner et al., *Nature* 373:441-444 (1995); Gougeon et al., *AIDS Res. Hum. Retroviruses* 9:553-563 (1993)) and, apoptosis is not observed in those animal models in which viral replication does not result in AIDS. *Id.* Further data indicates that uninfected but primed or activated T lymphocytes from HIV-infected individuals undergo apoptosis after encountering the TNF-family ligand FasL. Using monocytic cell lines that result in death following HIV infection, it has been demonstrated that infection of U937 cells with HIV results in the *de novo* expression of FasL and that FasL mediates HIV-induced apoptosis (Badley et al., *J. Virol.* 70:199-206 (1996)). Further, the TNF-family ligand was

detectable in uninfected macrophages and its expression was upregulated following HIV infection resulting in selective killing of uninfected CD4 T-lymphocytes. *Id.* Thus, by the invention, a method for treating HIV<sup>+</sup> individuals is provided which involves administering an antagonist of the present invention to reduce selective killing  
5 of CD4 T-lymphocytes. Modes of administration and dosages are discussed in detail below.

In rejection of an allograft, the immune system of the recipient animal has not previously been primed to respond because the immune system for the most part is only primed by environmental antigens. Tissues from other members of the same  
10 species have not been presented in the same way than, for example, viruses and bacteria have been presented. In the case of allograft rejection, immunosuppressive regimens are designed to prevent the immune system from reaching the effector stage. However, the immune profile of xenograft rejection may resemble disease recurrence more than allograft rejection. In the case of disease recurrence, the immune system has  
15 already been activated, as evidenced by destruction of the native islet cells. Therefore, in disease recurrence, the immune system is already at the effector stage. Agonists of the present invention are able to suppress the immune response to both allografts and xenografts because lymphocytes activated and differentiated into effector cells will express the TR9 polypeptide, and thereby are susceptible to compounds which  
20 enhance apoptosis. Thus, the present invention further provides a method for creating immune privileged tissues.

TR9 antagonists of the invention can further be used in the treatment of inflammatory diseases and stress response related diseases, such as inflammatory bowel disease, rheumatoid arthritis, osteoarthritis, psoriasis, and septicemia.

25 In addition, due to lymphoblast expression of TR9, soluble TR9 agonist or antagonist antibodies (e.g., mABs) may be used to treat this form of cancer. Further, soluble TR9 or neutralizing mABs may be used to treat various chronic and acute forms of inflammation such as rheumatoid arthritis, osteoarthritis, psoriasis, septicemia, and inflammatory bowel disease.



### *Modes of Administration*

The agonist or antagonists described herein can be administered *in vitro*, *ex vivo*, or *in vivo* to cells which express the receptor of the present invention. By administration of an "effective amount" of an agonist or antagonist is intended an amount of the compound that is sufficient to enhance or inhibit a cellular response to a TNF-family ligand and include polypeptides. In particular, by administration of an "effective amount" of an agonist or antagonists is intended an amount effective to enhance or inhibit TR9 mediated apoptosis. Of course, where it is desired for apoptosis to be enhanced, an agonist according to the present invention can be co-administered with a TNF-family ligand. One of ordinary skill will appreciate that effective amounts of an agonist or antagonist can be determined empirically and may be employed in pure form or in pharmaceutically acceptable salt, ester or prodrug form. The agonist or antagonist may be administered in compositions in combination with one or more pharmaceutically acceptable excipients (i.e., carriers).

It will be understood that, when administered to a human patient, the total daily usage of the compounds and compositions of the present invention will be decided by the attending physician within the scope of sound medical judgment. The specific therapeutically effective dose level for any particular patient will depend upon factors well known in the medical arts.

As a general proposition, the total pharmaceutically effective amount of TR9 polypeptide administered parenterally per dose will be in the range of about 1  $\mu\text{g/kg/day}$  to 10  $\text{mg/kg/day}$  of patient body weight, although, as noted above, this will be subject to therapeutic discretion. More preferably, this dose is at least 0.01  $\text{mg/kg/day}$ , and most preferably for humans between about 0.01 and 1  $\text{mg/kg/day}$  for the hormone. If given continuously, the TR9 polypeptide is typically administered at a dose rate of about 1  $\mu\text{g/kg/hour}$  to about 50  $\mu\text{g/kg/hour}$ , either by 1-4 injections per day or by continuous subcutaneous infusions, for example, using a mini-pump. An

intravenous bag solution may also be employed.

Dosaging may also be arranged in a patient specific manner to provide a predetermined concentration of an agonist or antagonist in the blood, as determined by the RIA technique. Thus patient dosaging may be adjusted to achieve regular on-going  
5      trough blood levels, as measured by RIA, on the order of from 50 to 1000 ng/ml, preferably 150 to 500 ng/ml.

Pharmaceutical compositions are provided comprising an agonist (including TR9 receptor polynucleotides, polypeptides or antibodies of the invention) or agonist (e.g., TR9 polynucleotides, polypeptides of the invention or antibodies thereto) of  
10      TR9 and a pharmaceutically acceptable carrier or excipient, which may be administered orally, rectally, parenterally, intracisternally, intravaginally, intraperitoneally, topically (as by powders, ointments, drops or transdermal patch), buccally, or as an oral or nasal spray. In one embodiment "pharmaceutically acceptable carrier" means a non-toxic solid, semisolid or liquid filler, diluent, encapsulating  
15      material or formulation auxiliary of any type. In a specific embodiment, "pharmaceutically acceptable" means approved by a regulatory agency of the federal or a state government or listed in the U.S. Pharmacopeia or other generally recognized pharmacopeia for use in animals, and more particularly humans. Nonlimiting examples of suitable pharmaceutical carriers according to this embodiment are  
20      provided in "Remington's Pharmaceutical Sciences" by E.W. Martin, and include sterile liquids, such as water and oils, including those of petroleum, animal, vegetable or synthetic origin, such as peanut oil, soybean oil, mineral oil, sesame oil and the like. Water is a preferred carrier when the pharmaceutical composition is administered intravenously. Saline solutions and aqueous dextrose and glycerol solutions can be  
25      employed as liquid carriers, particularly for injectable solutions.

The term "parenteral" as used herein refers to modes of administration which include intravenous, intramuscular, intraperitoneal, intrasternal, subcutaneous and intraarticular injection and infusion.

Pharmaceutical compositions of the present invention for parenteral injection can comprise pharmaceutically acceptable sterile aqueous or nonaqueous solutions, dispersions, suspensions or emulsions as well as sterile powders for reconstitution into sterile injectable solutions or dispersions just prior to use.

5           In addition to soluble TR9 polypeptides, TR9 polypeptides containing the transmembrane region can also be used when appropriately solubilized by including detergents, such as CHAPS or NP-40, with buffer.

### *Chromosome Assays*

10           The nucleic acid molecules of the present invention are also valuable for chromosome identification. The sequence is specifically targeted to and can hybridize with a particular location on an individual human chromosome. The mapping of DNAs to chromosomes according to the present invention is an important first step in correlating those sequences with genes associated with disease.

15           In certain preferred embodiments in this regard, the cDNA herein disclosed is used to clone genomic DNA of a TR9 receptor gene. This can be accomplished using a variety of well known techniques and libraries, which generally are available commercially. The genomic DNA then is used for *in situ* chromosome mapping using well known techniques for this purpose.

20           In addition, in some cases, sequences can be mapped to chromosomes by preparing PCR primers (preferably 15-25 bp) from the cDNA. Computer analysis of the 3' untranslated region of the gene is used to rapidly select primers that do not span more than one exon in the genomic DNA, thus complicating the amplification process. These primers are then used for PCR screening of somatic cell hybrids containing  
25 individual human chromosomes.

Fluorescence *in situ* hybridization ("FISH") of a cDNA clone to a metaphase chromosomal spread can be used to provide a precise chromosomal location in one step. This technique can be used with probes from the cDNA as short as 50 or 60 bp. For a review of this technique, see Verma et al., *Human Chromosomes: A Manual Of*

*Basic Techniques*, Pergamon Press, N.Y. (1988).

Once a sequence has been mapped to a precise chromosomal location, the physical position of the sequence on the chromosome can be correlated with genetic map data. Such data are found, for example, in V. McKusick, *Mendelian Inheritance In Man*, available on-line through Johns Hopkins University, Welch Medical Library. The relationship between genes and diseases that have been mapped to the same chromosomal region are then identified through linkage analysis (coinheritance of physically adjacent genes).

Next, it is necessary to determine the differences in the cDNA or genomic sequence between affected and unaffected individuals. If a mutation is observed in some or all of the affected individuals but not in any normal individuals, then the mutation is likely to be the causative agent of the disease.

Having generally described the invention, the same will be more readily understood by reference to the following examples, which are provided by way of illustration and are not intended as limiting.

### ***Examples***

#### ***Example 1: Expression and Purification of the TR9 Receptor in E. coli***

The bacterial expression vector pQE60 is used for bacterial expression in this example. (QIAGEN, Inc., 9259 Eton Avenue, Chatsworth, CA, 91311). pQE60 encodes ampicillin antibiotic resistance ("Amp<sup>r</sup>") and contains a bacterial origin of replication ("ori"), an IPTG inducible promoter, a ribosome binding site ("RBS"), six codons encoding histidine residues that allow affinity purification using nickel-nitrilotri-acetic acid ("Ni-NTA") affinity resin sold by QIAGEN, Inc., *supra*, and suitable single restriction enzyme cleavage sites. These elements are arranged such that a DNA fragment encoding a polypeptide may be inserted in such a way as to produce that polypeptide with the six His residues (i.e., a "6 X His tag") covalently linked to the carboxyl terminus of that polypeptide. However, in this example, the polypeptide

coding sequence is inserted such that translation of the six His codons is prevented and, therefore, the polypeptide is produced with no 6 X His tag.

The DNA sequence encoding the desired portion of the TR9 receptor protein lacking the hydrophobic leader sequence is amplified from the deposited cDNA clone using PCR oligonucleotide primers which anneal to the amino terminal sequences of the desired portion of the TR9 receptor protein and to sequences in the deposited construct 3' to the cDNA coding sequence. Additional nucleotides containing restriction sites to facilitate cloning in the pQE60 vector are added to the 5' and 3' sequences, respectively.

For cloning the mature protein, the 5' primer has the sequence:  
5' CGCCCATGGCTCAGCCAGAACAGAAG 3' (SEQ ID NO:11) containing the underlined NcoI restriction site followed by 17 nucleotides complementary to the amino terminal coding sequence of the mature TR9 receptor sequence in Figures 1A-D. One of ordinary skill in the art would appreciate, of course, that the point in the protein coding sequence where the 5' primer begins may be varied to amplify a desired portion of the complete protein shorter or longer than the mature form. The 3' primer has the sequence:

5' CGCAAGCTTTTAGGGCAAATGCTCATTG3' (SEQ ID NO:12) containing the underlined HindIII restriction site followed by 19 nucleotides complementary to the 3' end of the non-coding sequence in the TR9 receptor DNA sequence in Figures 1A-D.

The amplified TR9 receptor DNA fragments and the vector pQE60 are digested with NcoI and HindIII, and the digested DNAs are then ligated together. Insertion of the TR9 receptor DNA into the restricted pQE60 vector places the TR9 receptor protein coding region including its associated stop codon downstream from the IPTG-inducible promoter and in-frame with an initiating AUG. The associated stop codon prevents translation of the six histidine codons downstream of the insertion point.

The ligation mixture is transformed into competent *E. coli* cells using standard procedures such as those described in Sambrook et al., *Molecular Cloning: a*

*Laboratory Manual, 2nd Ed.*; Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y. (1989). *E. coli* strain M15/rep4, containing multiple copies of the plasmid pREP4, which expresses the *lac* repressor and confers kanamycin resistance ("Kan<sup>r</sup>"), is used in carrying out the illustrative example described herein. This strain, which is only one of many that are suitable for expressing TR9 receptor protein, is available commercially from QIAGEN, Inc., *supra*. Transformants are identified by their ability to grow on LB plates in the presence of ampicillin and kanamycin. Plasmid DNA is isolated from resistant colonies and the identity of the cloned DNA confirmed by restriction analysis, PCR and DNA sequencing.

Clones containing the desired constructs are grown overnight ("O/N") in liquid culture in LB media supplemented with both ampicillin (100 µg/ml) and kanamycin (25 µg/ml). The O/N culture is used to inoculate a large culture, at a dilution of approximately 1:25 to 1:250. The cells are grown to an optical density at 600 nm ("OD<sub>600</sub>") of between 0.4 and 0.6. Isopropyl-b-D-thiogalactopyranoside ("IPTG") is then added to a final concentration of 1 mM to induce transcription from the *lac* repressor sensitive promoter, by inactivating the *lacI* repressor. Cells subsequently are incubated further for 3 to 4 hours. Cells then are harvested by centrifugation.

The cells are then stirred for 3-4 hours at 4°C in 6M guanidine-HCl, pH8. The cell debris is removed by centrifugation, and the supernatant containing the TR9 receptor is dialyzed against 50 mM Na-acetate buffer pH6, supplemented with 200 mM NaCl. Alternatively, the protein can be successfully refolded by dialyzing it against 500 mM NaCl, 20% glycerol, 25 mM Tris/HCl pH7.4, containing protease inhibitors. After renaturation the protein can be purified by ion exchange, hydrophobic interaction and size exclusion chromatography. Alternatively, an affinity chromatography step such as an antibody column can be used to obtain pure TR9 receptor protein. The purified protein is stored at 4°C or frozen at -80°C.

***Example 2: Cloning and Expression of the TR9 Receptor Protein in a Baculovirus Expression System***

5 In this illustrative example, the plasmid shuttle vector pA2 is used to insert the cloned DNA encoding the complete protein, including its naturally associated secretory signal (leader) sequence, into a baculovirus to express the mature TR9 receptor protein, using standard methods as described in Summers et al., *A Manual of Methods for Baculovirus Vectors and Insect Cell Culture Procedures*, Texas Agricultural Experimental Station Bulletin No. 1555 (1987). This expression vector  
10 contains the strong polyhedrin promoter of the *Autographa californica* nuclear polyhedrosis virus (AcMNPV) followed by convenient restriction sites such as *Bam*HI and *Asp*718. The polyadenylation site of the simian virus 40 ("SV40") is used for efficient polyadenylation. For easy selection of recombinant virus, the plasmid contains the beta-galactosidase gene from *E. coli* under control of a weak *Drosophila*  
15 promoter in the same orientation, followed by the polyadenylation signal of the polyhedrin gene. The inserted genes are flanked on both sides by viral sequences for cell-mediated homologous recombination with wild-type viral DNA to generate viable virus that express the cloned polynucleotide.

Many other baculovirus vectors could be used in place of the vector above,  
20 such as pAc373, pVL941 and pAcIM1, as one skilled in the art would readily appreciate, as long as the construct provides appropriately located signals for transcription, translation, secretion and the like, including a signal peptide and an in-frame AUG as required. Such vectors are described, for instance, in Luckow et al., *Virology* 170:31-39 (1989).

25 The cDNA sequence encoding the full length TR9 protein in the deposited clone, including the AUG initiation codon and the naturally associated leader sequence shown in Figures 1A-D (SEQ ID NO:2), is amplified using PCR oligonucleotide primers corresponding to the 5' and 3' sequences of the gene. The 5' primer has the sequence:

5' CGCCCCGGGGCCATCATGGGGACCTCTCCGAGC 3' (SEQ ID NO:13) containing the underlined SmaI restriction enzyme site, an efficient signal for initiation of translation in eukaryotic cells, as described by Kozak, M., *J. Mol. Biol.* 196:947-950 (1987), followed by a number of bases of the sequence of the complete TR9 receptor protein shown in Figures 1A-D, beginning with the AUG initiation codon.

The 3' primer (for cloning the soluble form) has the sequence:

5' CGCGGTACCTTAGGGCAAATGCTCATTG 3' (SEQ ID NO:14) containing the underlined Asp718 restriction site followed by nucleotides complementary to the 3' noncoding sequence in Figures 1A-D.

10 The amplified fragment is isolated from a 1% agarose gel using a commercially available kit ("GeneClean," BIO 101 Inc., La Jolla, Ca.). The fragment then is digested with SmaI and Asp718 and again is purified on a 1% agarose gel. This fragment is designated herein "F1".

15 The plasmid is digested with the restriction enzymes SmaI and Asp718 and optionally, can be dephosphorylated using calf intestinal phosphatase, using routine procedures known in the art. The DNA is then isolated from a 1% agarose gel using a commercially available kit ("GeneClean" BIO 101 Inc., La Jolla, Ca.). This vector DNA is designated herein "V1".

20 Fragment F1 and the dephosphorylated plasmid V1 are ligated together with T4 DNA ligase. *E. coli* HB101 or other suitable *E. coli* hosts such as XL-1 Blue (Stratagene Cloning Systems, La Jolla, CA) cells are transformed with the ligation mixture and spread on culture plates. Bacteria are identified that contain the plasmid with the human TR9 receptor gene using the PCR method, in which one of the primers that is used to amplify the gene and the second primer is from well within the vector so that only those bacterial colonies containing the TR9 receptor gene fragment  
25 will show amplification of the DNA. The sequence of the cloned fragment is confirmed by DNA sequencing. This plasmid is designated herein pBacTR9.

Five  $\mu$ g of the plasmid pBacTR9 are co-transfected with 1.0  $\mu$ g of a commercially available linearized baculovirus DNA ("BaculoGold™ baculovirus



DNA", Pharmingen, San Diego, CA.), using the lipofection method described by Felgner et al., *Proc. Natl. Acad. Sci. USA* 84:7413-7417 (1987). One  $\mu\text{g}$  of BaculoGold™ virus DNA and 5  $\mu\text{g}$  of the plasmid pBacTR9 are mixed in a sterile well of a microtiter plate containing 50  $\mu\text{l}$  of serum-free Grace's medium (Life Technologies Inc., Rockville, MD). Afterwards, 10  $\mu\text{l}$  Lipofectin plus 90  $\mu\text{l}$  Grace's medium are added, mixed and incubated for 15 minutes at room temperature. Then the transfection mixture is added drop-wise to Sf9 insect cells (ATCC CRL 1711) seeded in a 35 mm tissue culture plate with 1 ml Grace's medium without serum. The plate is rocked back and forth to mix the newly added solution. The plate is then incubated for 5 hours at 27°C. After 5 hours the transfection solution is removed from the plate and 1 ml of Grace's insect medium supplemented with 10% fetal calf serum is added. The plate is put back into an incubator and cultivation is continued at 27°C for four days.

After four days the supernatant is collected and a plaque assay is performed, as described by Summers and Smith, *supra*. An agarose gel with "Blue Gal" (Life Technologies Inc., Rockville, MD.) is used to allow easy identification and isolation of gal-expressing clones, which produce blue-stained plaques. (A detailed description of a "plaque assay" of this type can also be found in the user's guide for insect cell culture and baculovirology distributed by Life Technologies Inc., Rockville, MD., page 9-10). After appropriate incubation, blue stained plaques are picked with the tip of a micropipettor (e.g., Eppendorf). The agar containing the recombinant viruses is then resuspended in a microcentrifuge tube containing 200  $\mu\text{l}$  of Grace's medium and the suspension containing the recombinant baculovirus is used to infect Sf9 cells seeded in 35 mm dishes. Four days later the supernatants of these culture dishes are harvested and then they are stored at 4°C. The recombinant virus is called V-TR9.

To verify the expression of the V-TR9 gene, Sf9 cells are grown in Grace's medium supplemented with 10% heat inactivated FBS. The cells are infected with the recombinant baculovirus V-TR9 at a multiplicity of infection ("MOI") of

about 2. Six hours later the medium is removed and is replaced with SF900 II medium minus methionine and cysteine (available from Life Technologies Inc., Rockville, MD). If radiolabeled proteins are desired, 42 hours later, 5  $\mu$ Ci of  $^{35}$ S-methionine and 5  $\mu$ Ci  $^{35}$ S-cysteine (available from Amersham) are added. The cells are further  
5 incubated for 16 hours and then they are harvested by centrifugation. The proteins in the supernatant as well as the intracellular proteins are analyzed by SDS-PAGE followed by autoradiography (if radiolabeled). Microsequencing of the amino acid sequence of the amino terminus of purified protein may be used to determine the amino terminal sequence of the mature protein and thus the cleavage point and length  
10 of the secretory signal peptide.

***Example 3: Cloning and Expression of TR9 in Mammalian Cells***

A typical mammalian expression vector contains the promoter element, which mediates the initiation of transcription of mRNA, the protein coding sequence, and  
15 signals required for the termination of transcription and polyadenylation of the transcript. Additional elements include enhancers, Kozak sequences and intervening sequences flanked by donor and acceptor sites for RNA splicing. Highly efficient transcription can be achieved with the early and late promoters from SV40, the long terminal repeats (LTRS) from Retroviruses, e.g., RSV, HTLV, HIV and the early  
20 promoter of the cytomegalovirus (CMV). However, cellular elements can also be used (e.g., the human actin promoter). Suitable expression vectors for use in practicing the present invention include, for example, vectors such as PSVL and PMSG (Pharmacia, Uppsala, Sweden), pRSVcat (ATCC 37152), pSV2dhfr (ATCC 37146) and pBC12MI (ATCC 67109). Mammalian host cells that could be used include, human  
25 Hela 293, H9 and Jurkat cells, mouse NIH3T3 and C127 cells, Cos 1, Cos 7 and CV 1, quail QC1-3 cells, mouse L cells and Chinese hamster ovary (CHO) cells.

Alternatively, the gene can be expressed in stable cell lines that contain the gene integrated into a chromosome. The co-transfection with a selectable marker such

as dhfr, gpt, neomycin, or hygromycin allows the identification and isolation of the transfected cells.

The transfected gene can also be amplified to express large amounts of the encoded protein. The dihydrofolate reductase (DHFR) marker is useful to develop cell lines that carry several hundred or even several thousand copies of the gene of interest. Another useful selection marker is the enzyme glutamine synthase (GS) (Murphy et al., *Biochem J.* 227:277-279 (1991); Bebbington et al., *Bio/Technology* 10:169-175 (1992)). Using these markers, the mammalian cells are grown in selective medium and the cells with the highest resistance are selected. These cell lines contain the amplified gene(s) integrated into a chromosome. Chinese hamster ovary (CHO) and NSO cells are often used for the production of proteins.

The expression vectors pC1 and pC4 contain the strong promoter (LTR) of the Rous Sarcoma Virus (Cullen et al., *Molec. Cell. Biol.* 5:438-447 (1985)) plus a fragment of the CMV-enhancer (Boshart et al., *Cell* 41:521-530 (1985)). Multiple cloning sites, e.g., with the restriction enzyme cleavage sites *Bam*HI, *Xba*I and *Asp*718, facilitate the cloning of the gene of interest. The vectors contain in addition the 3' intron, the polyadenylation and termination signal of the rat preproinsulin gene.

### ***Example 3(a): Cloning and Expression in COS Cells***

The expression plasmid, pTR9-HA, is made by cloning a cDNA encoding TR9 into the expression vector pcDNAI/Amp or pcDNAIII (which can be obtained from Invitrogen, Inc.).

The expression vector pcDNAI/Amp contains: (1) an *E. coli* origin of replication effective for propagation in *E. coli* and other prokaryotic cells; (2) an ampicillin resistance gene for selection of plasmid-containing prokaryotic cells; (3) an SV40 origin of replication for propagation in eukaryotic cells; (4) a CMV promoter, a polylinker, an SV40 intron; (5) several codons encoding a hemagglutinin fragment (i.e., an "HA" tag to facilitate purification) followed by a termination codon and polyadenylation signal arranged so that a cDNA can be conveniently placed under

expression control of the CMV promoter and operably linked to the SV40 intron and the polyadenylation signal by means of restriction sites in the polylinker. The HA tag corresponds to an epitope derived from the influenza hemagglutinin protein described by Wilson et al., *Cell* 37:767-778 (1984). The fusion of the HA tag to the target protein allows easy detection and recovery of the recombinant protein with an antibody that recognizes the HA epitope. pcDNAIII contains, in addition, the selectable neomycin marker.

A DNA fragment encoding the TR9 is cloned into the polylinker region of the vector so that recombinant protein expression is directed by the CMV promoter. The plasmid construction strategy is as follows. The TR9 cDNA of the deposited clone is amplified using primers that contain convenient restriction sites, much as described above for construction of vectors for expression of TR9 in *E. coli*. Suitable primers include the following, which are used in this example.

The 5' primer, containing the underlined SmaI site, a Kozak sequence, an AUG start codon and codons of the 5' coding region of the complete TR9 receptor has the following sequence: 5' CGCCCCGGGGCCATCATGGGGACCTCTCCGAGC 3' (SEQ ID NO:13).

The 3' primer, containing the underlined XbaI site, a stop codon, and nucleotides of the 3' coding sequence, has the following sequence (at the 3' end): 5'CGCTCTAGATCAAGCGTAGTCTGGGACGTCGTATGGGTAGGGCAAAT GCTCATTG3' (SEQ ID NO:15).

The PCR amplified DNA fragment and the vector, pcDNAI/Amp, are digested with SmaI and XbaI and then ligated. The ligation mixture is transformed into *E. coli* strain SURE (available from Stratagene Cloning Systems, 11099 North Torrey Pines Road, La Jolla, CA 92037), and the transformed culture is plated on ampicillin media plates which then are incubated to allow growth of ampicillin resistant colonies. Plasmid DNA is isolated from resistant colonies and examined by restriction analysis or other means for the presence of the TR9-encoding fragment.

For expression of recombinant TR9, COS cells are transfected with an expression vector, as described above, using DEAE-DEXTRAN, as described, for instance, in Sambrook *et al.*, *Molecular Cloning: a Laboratory Manual*, Cold Spring Laboratory Press, Cold Spring Harbor, N.Y. (1989). Cells are incubated under  
5 conditions for expression of TR9 by the vector.

Expression of the TR9-HA fusion protein is detected by radiolabeling and immunoprecipitation, using methods described in, for example Harlow *et al.*, *Antibodies: A Laboratory Manual, 2nd Ed.*; Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y. (1988). To this end, two days after transfection, the cells  
10 are labeled by incubation in media containing <sup>35</sup>S-cysteine for 8 hours. The cells and the media are collected, and the cells are washed and lysed with detergent-containing RIPA buffer: 150 mM NaCl, 1% NP-40, 0.1% SDS, 0.5% DOC, 50 mM TRIS, pH 7.5, as described by Wilson *et al.* cited above. Proteins are precipitated from the cell lysate and from the culture media using an HA-specific monoclonal antibody. The  
15 precipitated proteins then are analyzed by SDS-PAGE and autoradiography. An expression product of the expected size is seen in the cell lysate, which is not seen in negative controls.

***Example 3(b): Cloning and Expression in CHO Cells***

The vector pC4 is used for the expression of TR9 protein. Plasmid pC4 is a derivative of the plasmid pSV2-dhfr (ATCC Accession No. 37146). The plasmid contains the mouse DHFR gene under control of the SV40 early promoter. Chinese hamster ovary- or other cells lacking dihydrofolate activity that are transfected with these plasmids can be selected by growing the cells in a selective medium (alpha minus  
20 MEM, Life Technologies, Rockville, MD) supplemented with the chemotherapeutic agent methotrexate. The amplification of the DHFR genes in cells resistant to methotrexate (MTX) has been well documented (see, e.g., Alt *et al.*, *J. Biol. Chem.* 253:1357-1370 (1978); Hamlin *et al.*, *Biochem. et Biophys. Acta*, 1097:107-143 (1990); and Page *et al.*, *Biotechnology* 9:64-68 (1991)). Cells grown in increasing

concentrations of MTX develop resistance to the drug by overproducing the target enzyme, DHFR, as a result of amplification of the DHFR gene. If a second gene is linked to the DHFR gene, it is usually co-amplified and over-expressed. It is known in the art that this approach may be used to develop cell lines carrying more than 1,000 copies of the amplified gene(s). Subsequently, when the methotrexate is withdrawn, cell lines are obtained which contain the amplified gene integrated into one or more chromosome(s) of the host cell.

Plasmid pC4 contains for expressing the gene of interest the strong promoter of the long terminal repeat (LTR) of the Rous Sarcoma Virus (Cullen et al., *Molec. Cell. Biol.* 5:438-447 (1985)) plus a fragment isolated from the enhancer of the immediate early gene of human cytomegalovirus (CMV) (Boshart et al., *Cell* 41:521-530 (1985)). Downstream of the promoter are *Bam*HI, *Xba*I, and *Asp*718 restriction enzyme cleavage sites that allow integration of the genes. Behind these cloning sites the plasmid contains the 3' intron and polyadenylation site of the rat preproinsulin gene. Other high efficiency promoters can also be used for the expression, e.g., the human  $\beta$ -actin promoter, the SV40 early or late promoters or the long terminal repeats from other retroviruses, e.g., HIV and HTLVI. Clontech's Tet-Off and Tet-On gene expression systems and similar systems can be used to express the TR9 in a regulated way in mammalian cells (Gossen et. al., *Proc. Natl. Acad. Sci. USA* 89:5547-5551 (1992)). For the polyadenylation of the mRNA other signals, e.g., from the human growth hormone or globin genes can be used as well. Stable cell lines carrying a gene of interest integrated into the chromosomes can also be selected upon co-transfection with a selectable marker such as gpt, G418 or hygromycin. It is advantageous to use more than one selectable marker in the beginning, e.g., G418 plus methotrexate.

The plasmid pC4 is digested with the restriction enzymes *Sma*I and *Asp*718 and then dephosphorylated using calf intestinal phosphatase by procedures known in the art. The vector is then isolated from a 1% agarose gel.

The DNA sequence encoding the complete TR9 protein including its leader sequence is amplified using PCR oligonucleotide primers corresponding to the 5' and 3'

sequences of the gene.

The 5' primer has the sequence:

5' CGCCCCGGGGCCATCATGGGGACCTCTCCGAGC 3' (SEQ ID NO:13)  
restriction enzyme site, an efficient signal for initiation of translation in eukaryotic  
cells, as described by Kozak, M., *J. Mol. Biol.* 196:947-950 (1987), followed by a  
number of bases of the coding sequence of the TR9 receptor protein shown in Figures  
1A-D (SEQ ID NO:1).

The 3' primer (for cloning the soluble form) has the sequence:

5' CGCGGTACCTTAGGGCAAATGCTCATTG 3' (SEQ ID NO:14) containing the  
underlined Asp718 restriction site followed by nucleotides complementary to the  
non-translated region of the TR9 receptor gene shown in Figures 1A-D (SEQ ID  
NO:1).

The amplified fragment is digested with the endonucleases SmaI and then  
purified again on a 1% agarose gel. The isolated fragment and the dephosphorylated  
vector are then ligated with T4 DNA ligase. *E. coli* HB101 or XL-1 Blue cells are then  
transformed and bacteria are identified that contain the fragment inserted into plasmid  
pC4 using, for instance, restriction enzyme analysis.

Chinese hamster ovary cells lacking an active DHFR gene are used for  
transfection. Five µg of the expression plasmid pC4 is cotransfected with 0.5 µg of  
the plasmid pSV2-neo using lipofectin (Felgner *et al.*, *supra*). The plasmid pSV2neo  
contains a dominant selectable marker, the neo gene from Tn5 encoding an enzyme  
that confers resistance to a group of antibiotics including G418. The cells are seeded  
in alpha minus MEM supplemented with 1 mg/ml G418. After 2 days, the cells are  
trypsinized and seeded in hybridoma cloning plates (Greiner, Germany) in alpha  
minus MEM supplemented with 10, 25, or 50 ng/ml of methotrexate plus 1 mg/ml  
G418. After about 10-14 days single clones are trypsinized and then seeded in 6-well  
petri dishes or 10 ml flasks using different concentrations of methotrexate (50 nM,  
100 nM, 200 nM, 400 nM, 800 nM). Clones growing at the highest concentrations of  
methotrexate are then transferred to new 6-well plates containing even higher

concentrations of methotrexate (1  $\mu$ M, 2  $\mu$ M, 5  $\mu$ M, 10  $\mu$ M, 20  $\mu$ M). The same procedure is repeated until clones are obtained which grow at a concentration of 100-200  $\mu$ M. Expression of the desired gene product is analyzed, for instance, by SDS-PAGE and Western blot or by reverse phase HPLC analysis.

5

***Example 4: Tissue Distribution of TR9 mRNA Expression***

Northern blot analysis is carried out to examine TR9 gene expression in human tissues, using methods described by, among others, Sambrook *et al., supra*. A cDNA probe containing the entire nucleotide sequence of the TR9 protein (SEQ ID NO: 1) is labeled with  $^{32}$ P using the *rediprime*<sup>TM</sup> DNA labeling system (Amersham Life Science), according to manufacturer's instructions. After labeling, the probe was purified using a CHROMA SPIN-100<sup>TM</sup> column (Clontech Laboratories, Inc.), according to manufacturer's protocol number PT1200-1. The purified labeled probe is then used to examine various human tissues for TR9 mRNA.

10

15

Multiple Tissue Northern (MTN) blots containing various human tissues (H) or human immune system tissues (IM) are obtained from Clontech and are examined with the labeled probe using ExpressHyb<sup>TM</sup> hybridization solution (Clontech) according to manufacturer's protocol number PT1190-1. Following hybridization and washing, the blots are mounted and exposed to film at -70°C overnight, and films developed according to standard procedures.

20

***Example 5: TR9 Induced Apoptosis***

Overexpression of Fas/APO-1 and TNFR-1 in mammalian cells mimics receptor activation (M. Muzio *et al., Cell* 85:817-827 (1996); M. P. Boldin *et al., Cell* 85:803-815 (1996)). Thus, this system is utilized to study the functional role of TR9. Transient expression of TR9 in MCF7 breast carcinoma cells and 293 human embryonic kidney cells is investigated for induction of apoptosis.

25



### **Experimental Design**

Cell death assays are performed essentially as previously described (A.M. Chinnaiyan *et al.*, *Cell* 81:505-512 (1995); M.P. Boldin *et al.*, *J. Biol. Chem.* 270:7795-8 (1995); F.C. Kischkel *et al.*, *EMBO* 14:5579-5588 (1995); A.M. Chinnaiyan *et al.*, *J. Biol. Chem.* 271:4961-4965 (1996)). Briefly, MCF-7 human breast carcinoma clonal cell lines stably transfected with either vector alone, a CrmA expression construct (M. Tewari *et al.*, *J. Biol. Chem.* 270:3255-60 (1995)), or FADD-DN expression construct (A.M. Chinnaiyan *et al.*, *J. Biol. Chem.* 271:4961-4965 (1996)) are transiently transfected with pCMV- TR9- galatosidase in the presence of a ten-fold excess of pcDNA3 expression constructs encoding the indicated proteins using lipofectamine (GIBCO-BRL). 293 cells are likewise transfected using the CaPO4 method. The ICE family inhibitor z-VAD-fmk (Enzyme Systems Products, Dublin, CA) is added to the cells at a concentration of 10 M, 5 hrs after transfection. 32 hours following transfection, cells are fixed and stained with X-Gal as previously described (A.M. Chinnaiyan *et al.*, *Cell* 81:505-12 (1995); M.P. Boldin *et al.*, *J. Biol. Chem.* 270:7795-8 (1995); F.C. Kischkel *et al.*, *EMBO* 14:5579-5588 (1995)).

### **Results**

The affected cells will display morphological alterations typical of cells undergoing apoptosis, becoming rounded, condensed, and detaching from the dish. Similar to TNFR-1 and Fas/APO-1 (M. Muzio *et al.*, *Cell* 85:817-827 (1996); M. P. Boldin *et al.*, *Cell* 85:803-815 (1996); M. Tewari *et al.*, *J. Biol. Chem.* 270:3255-60 (1995)), TR9-induced apoptosis is blocked by the inhibitors of ICE-like proteases, CrmA and z-VAD-fmk.

### **Example 6: Characterization of TR9**

Members of the TNF receptor family are crucial modulators of inflammatory and cellular immune responses, and mediate a variety of biological functions, ranging

from cell proliferation, differentiation and apoptosis to cell survival (Nagata, S., *Cell* 88:355-365 (1997); Armitage, R. J., *Curr. Opin. Immuno.* 6:407-413 (1994); Golstein, P., *Curr. Biol.* 7:R750-R753 (1997); Baichwal et al., *Curr. Biol.* 7:R94-R96. (1997); Smith et al., *Cell* 76: 959-962 (1994); Anderson et al., *Nature* 390:175-179 (1997); and  
5 Cleveland et al., *Cell* 81:479-482 (1995)). This family of receptors is characterized by several extracellular, cysteine-rich motifs that compose the ligand binding domain (Armitage, R. J., *Curr. Opin. Immuno.* 6:407-413 (1994); and Smith et al., *Cell* 76: 959-962 (1994)). Upon ligation by their cognate ligands, these receptors engage a number of signal transduction pathways, including apoptosis, activation of NF  $\kappa$ B  
10 and JNK pathways that modulate the expression of genes involved in the immune and stress response (Smith et al., *Cell* 76: 959-962 (1994)).

Within the TNF receptor family, six members have emerged as a distinct subgroup termed death receptors; they contain a cytoplasmic death domain and activation of these receptors leads to engagement of components of the cell death  
15 pathway (Nagata, S., *Cell* 88:355-365 (1997); and Golstein, P., *Curr. Biol.* 7:R750-R753 (1997)). Transmission of the death signal is mediated by a series of homophilic protein-protein interactions involving the death domain and death effector domain that was originally defined as being present in the adaptor molecule FADD/MORT1 and the death protease caspase-8 (Chinnaiyan et al., *Semin. Immunol.* 9:66-67 (1997)).  
20 For example, when the death receptor CD95/Fas is ligated by cognate ligand or agonist antibody, the adaptor molecule FADD and the death protease caspase-8 are recruited to the signalling complex through interactions involving death and death effector domains, respectively (Chinnaiyan et al., *Semin. Immunol.* 9:66-67 (1997); Muzio et al., *Cell* 85: 817-827 (1996); and Boldin et al., *Cell* 85:803-815 (1996)). On  
25 approximation, caspase-8 undergoes an autoactivation, initiating activation of the downstream caspases, cleavage of death substrates and demise of the cell (Muzio et al., *J. Biol. Chem.* 273:2952-2956 (1997); Barinaga, M., *Science* 280:32-34 (1998); Salvesen et al., *Cell* 91:443-446 (1997); and Martin et al., *Cell* 82: 349-352 (1995)). In

contrast to CD-95 that directly engages the FADD-caspase-8 pathway (Muzio et al., *Cell* 85: 817-827 (1996); Boldin et al., *Cell* 85:803-815 (1996); Chinnaiyan et al., *Cell* 81:505-512 (1995); and Boldin et al., *J. Biol. Chem.* 270:7795-7789 (1995)), both TNFR1 and DR3 utilize a primary adaptor molecule termed TRADD, around which  
5 assembles the FADD-caspase-8 pathway, an NF  $\kappa$ B activating pathway involving the death domain-containing Ser/Thr kinase RIP and a JNK activating pathway that is mediated by the adaptor molecule TRAF2 (Hsu et al., *Cell* 81:495-504 (1995); Hsu et al., *Immunity* 4:387-396 (1996); Chinnaiyan et al., *Science* 274:990-992 (1996); Kitson et al., *Nature* 384:372-375 (1996); Yeh et al., *Immunity* 7:715-725 (1997); Lee et al.,  
10 *Immunity* 7:703-713 (1997); and Kelliher et al., *Immunity* 8:297-303 (1998). Finally, there exists a subsidiary death pathway involving the death domain-containing adaptor RAIDD that binds to caspase-2 and has been shown to be part of the TNFR1 receptor complex, although the exact physiologic relevance of this redundant pathway remains unclear (Duan et al., *Nature* 385:86-89 (1997); and Ahmad et al., *Cancer Res.*  
15 57:615-619 (1997).

Here, we report the identification and initial characterization of TR9, a new member of the TNF receptor family possessing a cytoplasmic death domain. TR9 induced apoptosis in mammalian cells and was capable of engaging the NF  $\kappa$ B and JNK pathways.

20

### Materials and methods

*Expression Constructs* -- TR9 (amino acid residues 42-655 as depicted in Figures 1A-D; amino acid residues 2-615 as presented in SEQ ID NO:2) and TR9 delta (amino acid residues 42-460 as depicted in Figures 1A-D; amino acid residues 2-420 as  
25 presented in SEQ ID NO:2) were cloned into pCMV1FLAG (IBI-Kodak) as in frame fusions to a TR9-terminal Preprotrypsin leader sequence and FLAG tag encoded by the vector. cDNAs were obtained by polymerase chain reaction using DNA oligo primers for TR9: 5'-GGAAGATCTGCCAGAACAGAAGGCCTCGAAT-3' (SEQ

- ID NO:16) and 5'-CCATCTTCCTGACCTGCTGTAGTCTAGAGCC-3' (SEQ ID NO:17) and for TR9 delta: 5'-GGAAGATCTGCCAGAACAGAAGGCCTC GAAT-3' (SEQ ID NO:16) and 5'-GCCGACCACGAGCGGGCCTAGTCT AGAGCC-3' (SEQ ID NO:18). Constructs encoding DR4, FADD, CD95, DR3, TRADD, ICH1-pro, RAIDD and RIP have been described previously (Chinnaiyan et al., *Cell* 81:505-512 (1995); Hsu et al., *Cell* 81:495-504 (1995); Hsu et al., *Immunity* 4:387-396 (1996); Chinnaiyan et al., *Science* 274:990-992 (1996); Kelliher et al., *Immunity* 8:297-303 (1998); and Pan et al., *Science* 276:111-113 (1997)).
- 10 *Apoptosis Assay* -- Cell death assays were performed as previously described (Chinnaiyan et al., *Cell* 81:505-512 (1995); and Pan et al., *Science* 276:111-113 (1997)). Both HeLa and MCF7 cells were transfected using the lipofectamine procedure (Life Technologies, Inc.) according to the manufacturer's instructions.
- 15 *Co-immunoprecipitation Assay* -- *In vivo* interaction assays have been described elsewhere (Chinnaiyan et al., *Cell* 81:505-512 (1995); and Pan et al., *Science* 276:111-113 (1997)). 293 cells were co-transfected with FLAG-TR9, FLAG-TR9 delta, FLAG-CD95, FLAG-DR3, FLAG-TNFR1, and ICH-1pro-FLAG, expression constructs using standard calcium phosphate precipitation. After transfection (at 38-20 40 hours), cell lysates were prepared and the FLAG-tagged expressed proteins were immunoprecipitated with FLAG M2 affinity gel (IBI-Kodak) and the presence of FADD, myc-tagged TRADD and RIP (myc-TRADD and myc-RIP), or RAIDD detected by immunoblotting with polyclonal antibody to FADD horseradish peroxidase (HRP)-conjugated antibody to myc (BMB), or polyclonal antibody to25 RAIDD.

*NF- $\kappa$ B Luciferase Assay* -- NF  $\kappa$ B luciferase assays were done as described elsewhere (Chinnaiyan et al., *Cell* 81:505-512 (1995); and Pan et al., *Science* 276:111-113 (1997)).

5     *JNK Activation Assay* -- 293 cells were cultured in MEM containing 10% FBS. Cells were plated in 6-well plates and transfected with TR9 expressing plasmid or vector alone at 60-70% confluency by the lipofectamine method according to the manufacturer's instructions. Forty hours post transfection, cell extracts were prepared in lysis buffer containing 20 mM HEPES, pH 7.4, 2 mM EDTA, 250 mM NaCl,  
10     0.1% NP-40, 2  $\mu$ g/ml leupeptin, 2  $\mu$ g/ml aprotinin, 1 mM PMSF, 0.5  $\mu$ g/ml benzamide, 1 mM DTT and 1mM orthovanadate. The C-jun kinase assay was performed by a modified method as described (Haridas et al., *Immunol.* 160:3152-3162 (1998)). Briefly, cell extracts (70  $\mu$ g) were subjected to immunoprecipitation with 0.03  $\mu$ g anti-JNK antibody for 30 min at 4°C. Immuno-complexes were collected  
15     by incubation with protein A/G-sepharose beads for 30 min at 4°C. The beads were extensively washed with lysis buffer (4 X 400  $\mu$ l) and kinase buffer (2 X 400  $\mu$ l: 20 mM HEPES, pH 7.4, 1 mM DTT, 25 mM NaCl) and the kinase reaction allowed to proceed for 15 min at 30°C with 2  $\mu$ g GST-Jun (1-79) in 20  $\mu$ l containing 20 mM HEPES, pH 7.4, 10 mM MgCl<sub>2</sub> 1 mM DTT and 10  $\mu$ Ci [ $\gamma$ <sup>32</sup>P]ATP. Reactions were  
20     stopped by the addition of 15  $\mu$ l SDS-sample buffer and resolved by SDS-polyacrylamide gel electrophoresis. GST-Jun (1-79) was visualized by staining with Coomassie Blue and the dried gel visualized following Phosphorimager analysis (Molecular Dynamics; Sunnyvale, CA) and quantitation by ImageQuant Software (Molecular Dynamics). A specific assay for JNK activity involved the co-  
25     transfection of 3 X 10<sup>6</sup> 293 cells with vector, or the CD40, TR9, or TR9 delta expression constructs (6.4  $\mu$ g) together with 2.4  $\mu$ g of a JNK-myc expression plasmid using the calcium phosphate precipitation method. After transfection (approximately

36 hours), cell extracts were prepared by lysis in NP 40 buffer (20 mM Tris-Cl, pH 8.0, 137 mM NaCl, 10% Glycerol, 2 mM EDTA, 5 mM Na<sub>2</sub>VO<sub>4</sub>, 0.5 mM PMSF and 1 % NP40) plus protease inhibitor cocktail (BMB). Immunoprecipitation of JNK-myc was performed using monoclonal anti-myc antibody (10 µg, Babco) and immunocomplexes precipitated with 20 µl protein G-sepharose (50% slurry, Sigma) and detected by blotting with anti-myc-HRP. FLAG tagged CD40, TR9, and TR9 delta were immunoprecipitated with anti-FLAG M2 affinity gel and detected by blotting with anti-FLAG antibody. The kinase assay utilized 2 µg GST Jun(1-79) as substrate, 50 mM ATP and 5 µCi γ<sup>32</sup>P]ATP in 30 µl kinase buffer (30 mM HEPES, pH 7.4, 7 mM Mn Cl<sub>2</sub>, 5 mM MgCl<sub>2</sub> and 1 mM DTT).

### Results and discussion

TR9 has a putative signal sequence (amino acid residues 1-41 as depicted in Figures 1A-D and 4A; amino acid residues -40 to 1 in SEQ ID NO:2), with the mature form predicted to start at amino acids 42 (Gln) as depicted in Figures 1A-D and 4A (Nielson et al., *Protein. Eng.* 10:1-6 (1997)). The extracellular portion (amino acid residues 42-350 as depicted in Figures 1A-D and 4A; amino acid residues 2-310 in SEQ ID NO:2) contains four TNFR-like cysteine-rich motifs of TR9 (amino acid residues 67-211 as depicted in Figures 1A-D; amino acid residues 27-171 in SEQ ID NO:2) that are most related to those of osteoprotegerin (OPG) and TNFR2 with 36% and 42% amino acid identities, respectively (Figure.4B; data not shown). A transmembrane domain (amino acids 351 to 370 as depicted in Figures 1A-D and 4A; residues 311 to 330 of SEQ ID NO:2) is followed by a 285-amino acid long cytoplasmic portion of the molecule that contains a death domain related to those of all known death receptors (Figure 4C), being most related to the death domain of TNFR1 (27.2%) and least like that of DR5 (19.7%). Curiously, unlike other death receptors that have death domains present in their COOH-terminus, the death domain in TR9 was located adjacent to the transmembrane domain followed by a 150 amino

acid tail. Interestingly, following the death domain was a putative leucine zipper sequence overlapping with a proline-rich region reminiscent of a SH3 domain-binding motif (Figure 4A) (Pawson et al., *Science* 278:2075-2080 (1997)).

5        *TR9 mRNA expression in human tissues and cancer cell lines* -- A 4-kb TR9 transcript was found in most human adult tissue, immune tissue, and cancer cell lines represented on Northern blots (Clontech) that were probed with TR9 cDNA according to the manufacturers instructions (data not shown). The transcript was abundant in heart, brain, placenta, pancreas, lymph node, thymus and prostate. Lower  
10        levels were detected in lung, skeletal muscle, kidney, testis, uterus, small intestine, colon, spleen, bone marrow, and fetal liver. However, adult liver and peripheral blood leukocytes expressed little TR9 mRNA. Additionally, smaller transcripts of 3.1 and 2.4 kb were observed in the testis and fetal liver, respectively.

15        Among human cancer cell lines, abundant levels of 4-kb transcript was detected in several nonlymphoid tumor cells, including cervical carcinoma Hela S3, colorectal adenocarcinoma SW480, lung carcinoma A549, and melanoma G361 cells. Significantly, less or no expression was observed in lines of hematopoietic origin (e.g., Raji, K562, and HL-60; data not shown).

20        *TR9 induces apoptosis in mammalian cells* -- Since ectopic expression of death receptors can induce cell death in a ligand-independent manner (Chinnaiyan et al., *Cell* 81:505-512 (1995); Boldin et al., *J. Biol. Chem.* 270:7795-7789 (1995); Chinnaiyan et al., *Science* 274:990-992 (1996); Kitson et al., *Nature* 384:372-375 (1996); and Pan et al., *Science* 276:111-113 (1997)), we tested if TR9 could induce apoptosis upon  
25        overexpression. When Hela S3 cervical carcinoma cells were transfected with a TR9-expressing construct, 43% of the transfected cells underwent morphological changes characteristic of apoptosis (Figure 5). As expected, deletion of the putative death domain (TR9 delta) abolished its killing activity. Significantly, TR9 was unable to induce cell death in human breast carcinoma MCF7 cells although they were very

sensitive to DR4 killing (Figure 5 and not shown), suggesting that the cell death pathway engaged by TR9 may be distinct from that engaged by other death receptors. Alternatively, the apoptotic activity of TR9 may be modulated by other signaling pathways it activates (see below) or ligand binding may be required to unveil its full killing capacity.

*Interaction of TR9 with adaptor molecules in vivo* -- Death receptors utilize the adaptor molecules FADD (for CD95) or both TRADD and FADD (for TNFR1 and DR3) to transmit the death signal (Chinnaiyan et al., *Cell* 81:505-512 (1995); Boldin et al., *J. Biol. Chem.* 270:7795-7789 (1995); Chinnaiyan et al., *Science* 274:990-992 (1996); and Kitson et al., *Nature* 384:372-375 (1996)). We thus determined if TR9 could bind any of these adaptor molecules in human embryonic kidney 293 cells. TR9 did not interact with FADD, although the association between CD95 and FADD was readily detected under similar conditions (data not shown). Interestingly, TR9 was found to associate with TRADD, although the interaction was weaker than that between DR3 and TRADD (data not shown). This observation is consistent with the observation that TR9 has a weaker killing ability. Alternatively, TR9 may use a TRADD-related molecule as an adaptor, or the observed association might be bridged by another adaptor protein. Interaction was not detectable between TR9 and RAIDD or RIP, two other adaptor molecules known to be recruited to the TNFR1 and DR3 signalling complexes (data not shown).

*TR9 activates nuclear factor- $\kappa$ B* -- Both TNFR1 and DR3 can engage a signal transduction pathway that leads to the activation of NF- $\kappa$ B (Smith et al., *Cell* 76: 959-962 (1994); Chinnaiyan et al., *Science* 274:990-992 (1996); Kitson et al., *Nature* 384:372-375 (1996); and Baker et al., *Oncogene* 12:1-9 (1996)). The ability of TR9 to activate NF- $\kappa$ B was tested in a luciferase reporter assay and was found to induce NF- $\kappa$ B activation in a dose-dependent manner (Figure 6). Presumably overexpressing



the receptor allowed it to achieve an active configuration that was competent to signal the NF- $\kappa$ B system. Interestingly, the cytoplasmic deletion of TR9 that abolished its apoptotic activity similarly abrogated its ability to activate NF- $\kappa$ B (data not shown), suggesting that these two signaling pathways may be mediated by a common receptor-proximal adapter molecule.

*Ectopic expression of TR9 induces JNK activation* -- JNK activation is known to be induced by several TNF receptors including TNFR1 and CD40 (Smith et al., *Cell* 76: 959-962 (1994); Yeh et al., *Immunity* 7:715-725 (1997); Lee et al., *Immunity* 7:703-713 (1997); and Baker et al., *Oncogene* 12:1-9 (1996)). We next determined whether overexpression of TR9 could lead to JNK activation using an in vitro kinase assay. TR9 was found to induce JNK activation in a dose-dependent manner (data not shown). The cytoplasmic truncation that attenuated cell death or NF- $\kappa$ B activation had surprisingly little effect on JNK activation (data not shown). This would be consistent with the notion that JNK activation is mediated by a cytoplasmic segment different from that responsible for apoptosis and NF- $\kappa$ B induction. It is noteworthy that two potential TRAF-binding motifs are present adjacent to the transmembrane domain PRQDP (amino acid residues 381-385 as depicted in Figures 1A-D; amino acid residues 341-345 as presented in SEQ ID NO:2), and PTQNR (amino acid residues 400-404 as depicted in Figures 1A-D; amino acid residues 360-364 as presented in SEQ ID NO:2) (Gedrich et al., *J. Biol. Chem.* 271:12852-12858 (1996) and Boucher et al., *Biochem. and Biophys. Res. Communi.* 233:592-600 (1997)).

In conclusion, we have identified a novel death domain-containing TNF receptor designated TR9. TR9 engages a cell death pathway different from those initiated by the CD95, TNFR1 or TRAIL/Apo2L receptors. In addition, TR9 also activates NF- $\kappa$ B and JNK, two signaling pathways shared by TNFR1. Thus, it is likely that like the other members of the TNF receptor family, TR9 plays a role in inflammatory responses and immune regulation.

It will be clear that the invention may be practiced otherwise than as particularly described in the foregoing description and examples.

Numerous modifications and variations of the present invention are possible in light of the above teachings and, therefore, are within the scope of the  
5 appended claims.

The entire disclosure of all publications (including patents, patent applications, journal articles, laboratory manuals, books, or other documents) cited herein are hereby incorporated by reference.

## SEQUENCE LISTING

## (1) GENERAL INFORMATION:

- (i) APPLICANT: Ni, Jian  
Yu, Guo-Liang  
Fan, Ping  
Gentz, Reiner
- (ii) TITLE OF INVENTION: Human Tumor Necrosis Factor Receptor TR9
- (iii) NUMBER OF SEQUENCES: 26
- (iv) CORRESPONDENCE ADDRESS:
  - (A) ADDRESSEE: Human Genome Sciences, Inc.
  - (B) STREET: 9410 Key West Avenue
  - (C) CITY: Rockville
  - (D) STATE: MD
  - (E) COUNTRY: US
  - (F) ZIP: 20850
- (v) COMPUTER READABLE FORM:
  - (A) MEDIUM TYPE: Floppy disk
  - (B) COMPUTER: IBM PC compatible
  - (C) OPERATING SYSTEM: PC-DOS/MS-DOS
  - (D) SOFTWARE: PatentIn Release #1.0, Version #1.30
- (vi) CURRENT APPLICATION DATA:
  - (A) APPLICATION NUMBER:
  - (B) FILING DATE:
  - (C) CLASSIFICATION:
- (viii) ATTORNEY/AGENT INFORMATION:
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## (2) INFORMATION FOR SEQ ID NO:1:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 3474 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear
- (ii) MOLECULE TYPE: DNA (genomic)
- (ix) FEATURE:
  - (A) NAME/KEY: CDS
  - (B) LOCATION: 247..2211
- (ix) FEATURE:
  - (A) NAME/KEY: mat\_peptide

(B) LOCATION: 367..2211

## (ix) FEATURE:

(A) NAME/KEY: sig\_peptide

(B) LOCATION: 247..364

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

GCGGGCTGCA GTCGCGGCGG CTTCTCCCCG CCTGGGCGGC CGCGCCGCTG GGCAGGTGCT	60
GAGCGCCCCT AGAGCCTCCC TTGCCGCCTC CCTCCTCTGC CCGGCCGAG CAGTGCACAT	120
GGGGTGTGG AGGTAGATGG GCTCCCGGCC CGGGAGGCGG CGGTGGATGC GGCCTGGGC	180
AGAAGCAGCC GCCGATTCCA GCTGCCCGC GCGCCCGGG CGCCCCTGCG AGTCCCCGGT	240
TCAGCC ATG GGG ACC TCT CCG AGC AGC AGC ACC GCC CTC GCC TCC TGC	288
Met Gly Thr Ser Pro Ser Ser Ser Thr Ala Leu Ala Ser Cys	
-40 -35 -30	
AGC CGC ATC GCC CGC CGA GCC ACA GCC ACG ATG ATC GCG GGC TCC CTT	336
Ser Arg Ile Ala Arg Arg Ala Thr Ala Thr Met Ile Ala Gly Ser Leu	
-25 -20 -15	
CTC CTG CTT GGA TTC CTT AGC ACC ACC ACA GCT CAG CCA GAA CAG AAG	384
Leu Leu Leu Gly Phe Leu Ser Thr Thr Thr Ala Gln Pro Glu Gln Lys	
-10 -5 1 5	
GCC TCG AAT CTC ATT GGC ACA TAC CGC CAT GTT GAC CGT GCC ACC GGC	432
Ala Ser Asn Leu Ile Gly Thr Tyr Arg His Val Asp Arg Ala Thr Gly	
10 15 20	
CAG GTG CTA ACC TGT GAC AAG TGT CCA GCA GGA ACC TAT GTC TCT GAG	480
Gln Val Leu Thr Cys Asp Lys Cys Pro Ala Gly Thr Tyr Val Ser Glu	
25 30 35	
CAT TGT ACC AAC ACA AGC CTG CGC GTC TGC AGC AGT TGC CCT GTG GGG	528
His Cys Thr Asn Thr Ser Leu Arg Val Cys Ser Ser Cys Pro Val Gly	
40 45 50	
ACC TTT ACC AGG CAT GAG AAT GGC ATA GAG AAA TGC CAT GAC TGT AGT	576
Thr Phe Thr Arg His Glu Asn Gly Ile Glu Lys Cys His Asp Cys Ser	
55 60 65 70	
CAG CCA TGC CCA TGG CCA ATG ATT GAG AAA TTA CCT TGT GCT GCC TTG	624
Gln Pro Cys Pro Trp Pro Met Ile Glu Lys Leu Pro Cys Ala Ala Leu	
75 80 85	
ACT GAC CGA GAA TGC ACT TGC CCA CCT GGC ATG TTC CAG TCT AAC GCT	672
Thr Asp Arg Glu Cys Thr Cys Pro Pro Gly Met Phe Gln Ser Asn Ala	
90 95 100	
ACC TGT GCC CCC CAT ACG GTG TGT CCT GTG GGT TGG GGT GTG CGG AAG	720
Thr Cys Ala Pro His Thr Val Cys Pro Val Gly Trp Gly Val Arg Lys	
105 110 115	
AAA GGG ACA GAG ACT GAG GAT GTG CGG TGT AAG CAG TGT GCT CGG GGT	768
Lys Gly Thr Glu Thr Glu Asp Val Arg Cys Lys Gln Cys Ala Arg Gly	
120 125 130	

ACC TTC TCA GAT GTG CCT TCT AGT GTG ATG AAA TGC AAA GCA TAC ACA Thr Phe Ser Asp Val Pro Ser Ser Val Met Lys Cys Lys Ala Tyr Thr 135 140 145 150	816
GAC TGT CTG AGT CAG AAC CTG GTG GTG ATC AAG CCG GGG ACC AAG GAG Asp Cys Leu Ser Gln Asn Leu Val Val Ile Lys Pro Gly Thr Lys Glu 155 160 165	864
ACA GAC AAC GTC TGT GGC ACA CTC CCG TCC TTC TCC AGC TCC ACC TCA Thr Asp Asn Val Cys Gly Thr Leu Pro Ser Phe Ser Ser Ser Thr Ser 170 175 180	912
CCT TCC CCT GGC ACA GCC ATC TTT CCA CGC CCT GAG CAC ATG GAA ACC Pro Ser Pro Gly Thr Ala Ile Phe Pro Arg Pro Glu His Met Glu Thr 185 190 195	960
CAT GAA GTC CCT TCC TCC ACT TAT GTT CCC AAA GGC ATG AAC TCA ACA His Glu Val Pro Ser Ser Thr Tyr Val Pro Lys Gly Met Asn Ser Thr 200 205 210	1008
GAA TCC AAC TCT TCT GCC TCT GTT AGA CCA AAG GTA CTG AGT AGC ATC Glu Ser Asn Ser Ser Ala Ser Val Arg Pro Lys Val Leu Ser Ser Ile 215 220 225 230	1056
CAG GAA GGG ACA GTC CCT GAC AAC ACA AGC TCA GCA AGG GGG AAG GAA Gln Glu Gly Thr Val Pro Asp Asn Thr Ser Ser Ala Arg Gly Lys Glu 235 240 245	1104
GAC GTG AAC AAG ACC CTC CCA AAC CTT CAG GTA GTC AAC CAC CAG CAA Asp Val Asn Lys Thr Leu Pro Asn Leu Gln Val Val Asn His Gln Gln 250 255 260	1152
GGC CCC CAC CAC AGA CAC ATC CTG AAG CTG CTG CCG TCC ATG GAG GCC Gly Pro His His Arg His Ile Leu Lys Leu Leu Pro Ser Met Glu Ala 265 270 275	1200
ACT GGG GGC GAG AAG TCC AGC ACG CCC ATC AAG GGC CCC AAG AGG GGA Thr Gly Gly Glu Lys Ser Ser Thr Pro Ile Lys Gly Pro Lys Arg Gly 280 285 290	1248
CAT CCT AGA CAG AAC CTA CAC AAG CAT TTT GAC ATC AAT GAG CAT TTG His Pro Arg Gln Asn Leu His Lys His Phe Asp Ile Asn Glu His Leu 295 300 305 310	1296
CCC TGG ATG ATT GTG CTT TTC CTG CTG CTG GTG CTT GTG GTG ATT GTG Pro Trp Met Ile Val Leu Phe Leu Leu Leu Val Leu Val Val Ile Val 315 320 325	1344
GTG TGC AGT ATC CCG AAA AGC TCG AGG ACT CTG AAA AAG GGG CCC CGG Val Cys Ser Ile Arg Lys Ser Ser Arg Thr Leu Lys Lys Gly Pro Arg 330 335 340	1392
CAG GAT CCC AGT GCC ATT GTG GAA AAG GCA GGG CTG AAG AAA TCC ATG Gln Asp Pro Ser Ala Ile Val Glu Lys Ala Gly Leu Lys Lys Ser Met 345 350 355	1440
ACT CCA ACC CAG AAC CGG GAG AAA TGG ATC TAC TAC TGC AAT GGC CAT Thr Pro Thr Gln Asn Arg Glu Lys Trp Ile Tyr Tyr Cys Asn Gly His 360 365 370	1488

GGT ATC GAT ATC CTG AAG CTT GTA GCA GCC CAA GTG GGA AGC CAG TGG Gly Ile Asp Ile Leu Lys Leu Val Ala Ala Gln Val Gly Ser Gln Trp 375 380 385 390	1536
AAA GAT ATC TAT CAG TTT CTT TGC AAT GCC AGT GAG AGG GAG GTT GCT Lys Asp Ile Tyr Gln Phe Leu Cys Asn Ala Ser Glu Arg Glu Val Ala 395 400 405	1584
GCT TTC TCC AAT GGG TAC ACA GCC GAC CAC GAG CGG GCC TAC GCA GCT Ala Phe Ser Asn Gly Tyr Thr Ala Asp His Glu Arg Ala Tyr Ala Ala 410 415 420	1632
CTG CAG CAC TGG ACC ATC CGG GGC CCC GAG GCC AGC CTC GCC CAG CTA Leu Gln His Trp Thr Ile Arg Gly Pro Glu Ala Ser Leu Ala Gln Leu 425 430 435	1680
ATT AGC GCC CTG CGC CAG CAC CGG AGA AAC GAT GTT GTG GAG AAG ATT Ile Ser Ala Leu Arg Gln His Arg Arg Asn Asp Val Val Glu Lys Ile 440 445 450	1728
CGT GGG CTG ATG GAA GAC ACC ACC CAG CTG GAA ACT GAC AAA CTA GCT Arg Gly Leu Met Glu Asp Thr Thr Gln Leu Glu Thr Asp Lys Leu Ala 455 460 465 470	1776
CTC CCG ATG AGC CCC AGC CCG CTT AGC CCG AGC CCC ATC CCC AGC CCC Leu Pro Met Ser Pro Ser Pro Leu Ser Pro Ser Pro Ile Pro Ser Pro 475 480 485	1824
AAC GCG AAA CTT GAG AAT TCC GCT CTC CTG ACG GTG GAG CCT TCC CCA Asn Ala Lys Leu Glu Asn Ser Ala Leu Thr Val Glu Pro Ser Pro 490 495 500	1872
CAG GAC AAG AAC AAG GGC TTC TTC GTG GAT GAG TCG GAG CCC CTT CTC Gln Asp Lys Asn Lys Gly Phe Phe Val Asp Glu Ser Glu Pro Leu Leu 505 510 515	1920
CGC TGT GAC TCT ACA TCC AGC GGC TCC TCC GCG CTG AGC AGG AAC GGT Arg Cys Asp Ser Thr Ser Ser Gly Ser Ser Ala Leu Ser Arg Asn Gly 520 525 530	1968
TCC TTT ATT ACC AAA GAA AAG AAG GAC ACA GTG TTG CGG CAG GTA CGC Ser Phe Ile Thr Lys Glu Lys Lys Asp Thr Val Leu Arg Gln Val Arg 535 540 545 550	2016
CTG GAC CCC TGT GAC TTG CAG CCT ATC TTT GAT GAC ATG CTC CAC TTT Leu Asp Pro Cys Asp Leu Gln Pro Ile Phe Asp Asp Met Leu His Phe 555 560 565	2064
CTA AAT CCT GAG GAG CTG CGG GTG ATT GAA GAG ATT CCC CAG GCT GAG Leu Asn Pro Glu Glu Leu Arg Val Ile Glu Glu Ile Pro Gln Ala Glu 570 575 580	2112
GAC AAA CTA GAC CGG CTA TTC GAA ATT ATT GGA GTC AAG AGC CAG GAA Asp Lys Leu Asp Arg Leu Phe Glu Ile Ile Gly Val Lys Ser Gln Glu 585 590 595	2160
GCC AGC CAG ACC CTC CTG GAC TCT GTT TAT AGC CAT CTT CCT GAC CTG Ala Ser Gln Thr Leu Leu Asp Ser Val Tyr Ser His Leu Pro Asp Leu 600 605 610	2208

CTG TAGAACATAG GGATACTGCA TTCTGGAAAT TACTCAATTT AGTGGCAGGG 2261  
 Leu  
 615

TGGTTTTTTA ATTTTCTTCT GTTCTGATT TTTGTTGTTT GGGGTGTGTG TGTGTGTTTG 2321

TGTGTGTGTG TGTGTGTGTG TGTGTGTGTG TGTGTGTGTG TTTAACAGAG AATATGGCCA 2381

GTGCTTGAGT TCTTTCTCCT TCTCTCTCTC TTTTTTTTTT AAATAACTCT TCTGGGAAGT 2441

TGGTTTATAA GCCTTTGCCA GGTGTAAC TG TG TGAATA CCCACCACTA AAGTTTTTTA 2501

AGTTCATAT TTTCTCCATT TTGCCTTCTT ATGTATTTTC GAGATTATTC TGTGCACTTT 2561

AAATTTACTT AACTTACCAT AAATGCAGTG TGACTTTTCC CACACACTGG ATTGTGAGGC 2621

TCTTAACTTC TTAAAAGTAT AATGGCATCT TGTGAATCCT ATAAGCAGTC TTTATGTCTC 2681

TTAACATTCA CACCTACTTT TTAAAAACAA ATATTATTAC TATTTTTATT ATTGTTTGTC 2741

CTTTATAAAT TTTCTTAAAG ATTAAGAAAA TTTAAGACCC CATTGAGTTA CTGTAATGCA 2801

ATTCAACTTT GAGTTATCTT TTAAATATGT CTGTATAGT TCATATTCAT GGCTGAAACT 2861

TGACCACACT ATTGCTGATT GTATGGTTT CACCTGGACA CCGTGTAGAA TGCTTGATTA 2921

CTGTACTCT TCTTATGCTA ATATGCTCTG GGCTGGAGAA ATGAAATCCT CAAGCCATCA 2981

GGATTTGCTA TTTAAGTGGC TTGACAACTG GGCCACCAAA GAACTTGAAC TTCACCTTTT 3041

AGGATTTGAG CTGTTCTGGA ACACATTGCT GCACTTTGGA AAGTCAAAAT CAAGTGCCAG 3101

TGGCGCCCTT TCCATAGAGA ATTTGCCCAG CTTTGCTTTA AAAGATGTCT TGTTTTTTAT 3161

ATACACATAA TCAATAGGTC CAATCTGCTC TCAAGGCCTT GGTCTGGTG GGATTCCTTC 3221

ACCAATTACT TTAATTAAAA ATGGCTGCAA CTGTAAGAAC CCTGTCTGA TATATTTGCA 3281

ACTATGCTCC CATTTACAAA TGTACCTTCT AATGCTCAGT TGCCAGGTTT CAATGCAAAG 3341

GTGGCGTGGA CTCCCTTTGT GTGGGTGGG TTTGTGGGTA GTGGTGAAGG ACCGATATCA 3401

GAAAAATGCC TTCAAGTGA CTAATTTATT AATAAACATT AGGTGTTTGT TAAAAAATA 3461

AAAAAAAAA AAA 3474

## (2) INFORMATION FOR SEQ ID NO:2:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 655 amino acids
- (B) TYPE: amino acid
- (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: protein

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

Met Gly Thr Ser Pro Ser Ser Ser Thr Ala Leu Ala Ser Cys Ser Arg

94

-40                      -35                      -30                      -25  
 Ile Ala Arg Arg Ala Thr Ala Thr Met Ile Ala Gly Ser Leu Leu Leu  
                                  -20                      -15                      -10  
 Leu Gly Phe Leu Ser Thr Thr Thr Ala Gln Pro Glu Gln Lys Ala Ser  
                                  -5                      1                      5  
 Asn Leu Ile Gly Thr Tyr Arg His Val Asp Arg Ala Thr Gly Gln Val  
                                  10                      15                      20  
 Leu Thr Cys Asp Lys Cys Pro Ala Gly Thr Tyr Val Ser Glu His Cys  
                                  25                      30                      35                      40  
 Thr Asn Thr Ser Leu Arg Val Cys Ser Ser Cys Pro Val Gly Thr Phe  
                                  45                      50                      55  
 Thr Arg His Glu Asn Gly Ile Glu Lys Cys His Asp Cys Ser Gln Pro  
                                  60                      65                      70  
 Cys Pro Trp Pro Met Ile Glu Lys Leu Pro Cys Ala Ala Leu Thr Asp  
                                  75                      80                      85  
 Arg Glu Cys Thr Cys Pro Pro Gly Met Phe Gln Ser Asn Ala Thr Cys  
                                  90                      95                      100  
 Ala Pro His Thr Val Cys Pro Val Gly Trp Gly Val Arg Lys Lys Gly  
                                  105                      110                      115                      120  
 Thr Glu Thr Glu Asp Val Arg Cys Lys Gln Cys Ala Arg Gly Thr Phe  
                                  125                      130                      135  
 Ser Asp Val Pro Ser Ser Val Met Lys Cys Lys Ala Tyr Thr Asp Cys  
                                  140                      145                      150  
 Leu Ser Gln Asn Leu Val Val Ile Lys Pro Gly Thr Lys Glu Thr Asp  
                                  155                      160                      165  
 Asn Val Cys Gly Thr Leu Pro Ser Phe Ser Ser Ser Thr Ser Pro Ser  
                                  170                      175                      180  
 Pro Gly Thr Ala Ile Phe Pro Arg Pro Glu His Met Glu Thr His Glu  
                                  185                      190                      195                      200  
 Val Pro Ser Ser Thr Tyr Val Pro Lys Gly Met Asn Ser Thr Glu Ser  
                                  205                      210                      215  
 Asn Ser Ser Ala Ser Val Arg Pro Lys Val Leu Ser Ser Ile Gln Glu  
                                  220                      225                      230  
 Gly Thr Val Pro Asp Asn Thr Ser Ser Ala Arg Gly Lys Glu Asp Val  
                                  235                      240                      245  
 Asn Lys Thr Leu Pro Asn Leu Gln Val Val Asn His Gln Gln Gly Pro  
                                  250                      255                      260  
 His His Arg His Ile Leu Lys Leu Leu Pro Ser Met Glu Ala Thr Gly  
                                  265                      270                      275                      280  
 Gly Glu Lys Ser Ser Thr Pro Ile Lys Gly Pro Lys Arg Gly His Pro



285	290	295
Arg Gln Asn Leu His Lys His Phe Asp Ile Asn Glu His Leu Pro Trp		
300	305	310
Met Ile Val Leu Phe Leu Leu Leu Val Leu Val Val Ile Val Val Cys		
315	320	325
Ser Ile Arg Lys Ser Ser Arg Thr Leu Lys Lys Gly Pro Arg Gln Asp		
330	335	340
Pro Ser Ala Ile Val Glu Lys Ala Gly Leu Lys Lys Ser Met Thr Pro		
345	350	355
Thr Gln Asn Arg Glu Lys Trp Ile Tyr Tyr Cys Asn Gly His Gly Ile		
365	370	375
Asp Ile Leu Lys Leu Val Ala Ala Gln Val Gly Ser Gln Trp Lys Asp		
380	385	390
Ile Tyr Gln Phe Leu Cys Asn Ala Ser Glu Arg Glu Val Ala Ala Phe		
395	400	405
Ser Asn Gly Tyr Thr Ala Asp His Glu Arg Ala Tyr Ala Ala Leu Gln		
410	415	420
His Trp Thr Ile Arg Gly Pro Glu Ala Ser Leu Ala Gln Leu Ile Ser		
425	430	435
Ala Leu Arg Gln His Arg Arg Asn Asp Val Val Glu Lys Ile Arg Gly		
445	450	455
Leu Met Glu Asp Thr Thr Gln Leu Glu Thr Asp Lys Leu Ala Leu Pro		
460	465	470
Met Ser Pro Ser Pro Leu Ser Pro Ser Pro Ile Pro Ser Pro Asn Ala		
475	480	485
Lys Leu Glu Asn Ser Ala Leu Leu Thr Val Glu Pro Ser Pro Gln Asp		
490	495	500
Lys Asn Lys Gly Phe Phe Val Asp Glu Ser Glu Pro Leu Leu Arg Cys		
505	510	515
Asp Ser Thr Ser Ser Gly Ser Ser Ala Leu Ser Arg Asn Gly Ser Phe		
525	530	535
Ile Thr Lys Glu Lys Lys Asp Thr Val Leu Arg Gln Val Arg Leu Asp		
540	545	550
Pro Cys Asp Leu Gln Pro Ile Phe Asp Asp Met Leu His Phe Leu Asn		
555	560	565
Pro Glu Glu Leu Arg Val Ile Glu Glu Ile Pro Gln Ala Glu Asp Lys		
570	575	580
Leu Asp Arg Leu Phe Glu Ile Ile Gly Val Lys Ser Gln Glu Ala Ser		
585	590	595
Gln Thr Leu Leu Asp Ser Val Tyr Ser His Leu Pro Asp Leu Leu		

605

610

615

## (2) INFORMATION FOR SEQ ID NO:3:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 281 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: single

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

```

Met Leu Gly Ile Trp Thr Leu Leu Pro Leu Val Leu Thr Ser Val Ala
 1             5             10             15
Arg Leu Ser Ser Lys Ser Val Asn Ala Gln Val Thr Asp Ile Asn Ser
      20             25             30
Lys Gly Leu Glu Leu Arg Lys Thr Val Thr Thr Val Glu Thr Gln Asn
      35             40             45
Leu Glu Gly Leu His His Asp Gly Gln Phe Cys His Lys Pro Cys Pro
      50             55             60
Pro Gly Glu Arg Lys Ala Arg Asp Cys Thr Val Asn Gly Asp Glu Pro
      65             70             75             80
Asp Cys Val Pro Cys Gln Glu Gly Lys Glu Tyr Thr Asp Lys Ala His
      85             90             95
Phe Ser Ser Lys Cys Arg Arg Cys Arg Leu Cys Asp Glu Gly His Gly
      100            105            110
Leu Glu Val Glu Ile Asn Cys Thr Arg Thr Gln Asn Thr Lys Cys Arg
      115            120            125
Cys Lys Pro Asn Phe Phe Cys Asn Ser Thr Val Cys Glu His Cys Asp
      130            135            140
Pro Cys Thr Lys Cys Glu His Gly Ile Ile Lys Glu Cys Thr Leu Thr
      145            150            155            160
Ser Asn Thr Lys Cys Lys Glu Glu Gly Ser Arg Ser Asn Leu Gly Trp
      165            170            175
Leu Cys Leu Leu Leu Leu Pro Ile Pro Leu Ile Val Trp Val Lys Arg
      180            185            190
Lys Glu Val Gln Lys Thr Cys Arg Lys His Arg Lys Glu Asn Gln Gly
      195            200            205
Ser His Glu Ser Pro Thr Leu Asn Pro Glu Thr Val Ala Ile Asn Leu
      210            215            220
Ser Asp Val Asp Leu Ser Lys Tyr Ile Thr Thr Ile Ala Gly Val Met

```

225		230		235		240									
Thr	Leu	Ser	Gln	Val	Lys	Ala	Asn	Leu	Cys	Thr	Leu	Ala	Glu	Lys	Ile
				245					250					255	
Gln	Thr	Ile	Ile	Leu	Lys	Asp	Ile	Thr	Ser	Asp	Ser	Glu	Asn	Ser	Asn
				260				265					270		
Phe	Arg	Asn	Glu	Ile	Gln	Ser	Leu	Val							
			275				280								

## (2) INFORMATION FOR SEQ ID NO:4:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 455 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: protein

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

Met	Gly	Ala	Gly	Ala	Thr	Gly	Arg	Ala	Met	Asp	Gly	Pro	Arg	Leu	Leu
1				5					10					15	
Leu	Leu	Leu	Leu	Leu	Gly	Val	Ser	Leu	Gly	Gly	Ala	Lys	Glu	Ala	Cys
				20			25						30		
Pro	Thr	Gly	Leu	Tyr	Thr	His	Ser	Gly	Glu	Cys	Cys	Lys	Ala	Cys	Asn
		35				40						45			
Leu	Gly	Glu	Gly	Val	Ala	Gln	Pro	Cys	Gly	Ala	Asn	Gln	Thr	Val	Cys
	50					55					60				
Glu	Pro	Cys	Leu	Asp	Ser	Val	Thr	Phe	Ser	Asp	Val	Val	Ser	Ala	Thr
65					70				75					80	
Glu	Pro	Cys	Lys	Pro	Cys	Thr	Glu	Cys	Val	Gly	Leu	Gln	Ser	Met	Ser
			85						90					95	
Ala	Pro	Cys	Val	Glu	Ala	Asp	Asp	Ala	Val	Cys	Arg	Cys	Ala	Tyr	Gly
			100					105					110		
Tyr	Tyr	Gln	Asp	Glu	Thr	Thr	Gly	Arg	Cys	Glu	Ala	Cys	Arg	Val	Cys
		115					120						125		
Glu	Ala	Gly	Ser	Gly	Leu	Val	Phe	Ser	Cys	Gln	Asp	Lys	Gln	Asn	Thr
	130					135						140			
Val	Cys	Glu	Glu	Cys	Pro	Asp	Gly	Thr	Tyr	Ser	Asp	Glu	Ala	Asn	His
145					150				155					160	
Val	Asp	Pro	Cys	Leu	Pro	Cys	Thr	Val	Cys	Glu	Asp	Thr	Glu	Arg	Gln
			165					170					175		
Leu	Arg	Glu	Cys	Thr	Arg	Trp	Ala	Asp	Ala	Glu	Cys	Glu	Glu	Ile	Pro

180										185										190																									
Gly	Arg	Trp	Ile	Thr	Arg	Ser	Thr	Pro	Pro	Glu	Gly	Ser	Asp	Ser	Thr																														
195										200										205																									
Ala	Pro	Ser	Thr	Gln	Glu	Pro	Glu	Ala	Pro	Pro	Glu	Gln	Asp	Leu	Ile																														
210										215										220																									
Ala	Ser	Thr	Val	Ala	Gly	Val	Val	Thr	Thr	Val	Met	Gly	Ser	Ser	Gln																														
225										230										235																									
Pro	Val	Val	Thr	Arg	Gly	Thr	Thr	Asp	Asn	Leu	Ile	Pro	Val	Tyr	Cys																														
245										250										255																									
Ser	Ile	Leu	Ala	Ala	Val	Val	Val	Gly	Leu	Val	Ala	Tyr	Ile	Ala	Phe																														
260										265										270																									
Lys	Arg	Trp	Asn	Ser	Cys	Lys	Gln	Asn	Lys	Gln	Gly	Ala	Asn	Ser	Arg																														
275										280										285																									
Pro	Val	Asn	Gln	Thr	Pro	Pro	Pro	Glu	Gly	Glu	Lys	Leu	His	Ser	Asp																														
290										295										300																									
Ser	Gly	Ile	Ser	Val	Asp	Ser	Gln	Ser	Leu	His	Asp	Gln	Gln	Pro	His																														
305										310										315																									
Thr	Gln	Thr	Ala	Ser	Gly	Gln	Ala	Leu	Lys	Gly	Asp	Gly	Gly	Leu	Tyr																														
325										330										335																									
Ser	Ser	Leu	Pro	Pro	Ala	Lys	Arg	Glu	Glu	Val	Glu	Lys	Leu	Leu	Asn																														
340										345										350																									
Gly	Ser	Ala	Gly	Asp	Thr	Trp	Arg	His	Leu	Ala	Gly	Glu	Leu	Gly	Tyr																														
355										360										365																									
Gln	Pro	Glu	His	Ile	Asp	Ser	Phe	Thr	His	Glu	Ala	Cys	Pro	Val	Arg																														
370										375										380																									
Ala	Leu	Leu	Ala	Ser	Trp	Ala	Thr	Gln	Asp	Ser	Ala	Thr	Leu	Pro	Arg																														
385										390										395																									
Arg	Glu	Val	Ala	Pro	Pro	Tyr	Gln	Gly	Ala	Asp	Pro	Ile	Leu	Ala	Thr																														
405										410										415																									
Ala	Leu	Ala	Ser	Asp	Pro	Ile	Pro	Asn	Pro	Leu	Gln	Lys	Trp	Glu	Asp																														
420										425										430																									
Ser	Ala	His	Lys	Pro	Gln	Ser	Leu	Asp	Thr	Asp	Asp	Pro	Cys	Ser	Glu																														
435										440										445																									
Ser	Thr	Ala	Thr	Ser	Pro	Val																																							
450										455																																			

## (2) INFORMATION FOR SEQ ID NO:5:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 455 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

```

Met Gly Leu Ser Thr Val Pro Asp Leu Leu Leu Pro Leu Val Leu Leu
 1           5           10           15

Glu Leu Leu Val Gly Ile Tyr Pro Ser Gly Val Ile Gly Leu Val Pro
 20           25           30

His Leu Gly Asp Arg Glu Lys Arg Asp Ser Val Cys Pro Gln Gly Lys
 35           40           45

Tyr Ile His Pro Gln Asn Asn Ser Ile Cys Cys Thr Lys Cys His Lys
 50           55           60

Gly Thr Tyr Leu Tyr Asn Asp Cys Pro Gly Pro Gly Gln Asp Thr Asp
 65           70           75           80

Cys Arg Glu Cys Glu Ser Gly Ser Phe Thr Ala Ser Glu Asn His Leu
 85           90           95

Arg His Cys Leu Ser Cys Ser Lys Cys Arg Lys Glu Met Gly Gln Val
100           105           110

Glu Ile Ser Ser Cys Thr Val Asp Arg Asp Thr Val Cys Gly Cys Arg
115           120           125

Lys Asn Gln Tyr Arg His Tyr Trp Ser Glu Asn Leu Phe Gln Cys Phe
130           135           140

Asn Cys Ser Leu Cys Leu Asn Gly Thr Val His Leu Ser Cys Gln Glu
145           150           155           160

Lys Gln Asn Thr Val Cys Thr Cys His Ala Gly Phe Phe Leu Arg Glu
165           170           175

Asn Glu Cys Val Ser Cys Ser Asn Cys Lys Lys Ser Leu Glu Cys Thr
180           185           190

Lys Leu Cys Leu Pro Gln Ile Glu Asn Val Lys Gly Thr Glu Asp Ser
195           200           205

Gly Thr Thr Val Leu Leu Pro Leu Val Ile Phe Phe Gly Leu Cys Leu
210           215           220

Leu Ser Leu Leu Phe Ile Gly Leu Met Tyr Arg Tyr Gln Arg Trp Lys
225           230           235           240

Ser Lys Leu Tyr Ser Ile Val Cys Gly Lys Ser Thr Pro Glu Lys Glu
245           250           255

Gly Glu Leu Glu Gly Thr Thr Thr Lys Pro Leu Ala Pro Asn Pro Ser
260           265           270

Phe Ser Pro Thr Pro Gly Phe Thr Pro Thr Leu Gly Phe Ser Pro Val

```

100

275	280	285
Pro Ser Ser Thr Phe Thr Ser Ser Ser Thr Tyr Thr Pro Gly Asp Cys		
290	295	300
Pro Asn Phe Ala Ala Pro Arg Arg Glu Val Ala Pro Pro Tyr Gln Gly		
305	310	315 320
Ala Asp Pro Ile Leu Ala Thr Ala Leu Ala Ser Asp Pro Ile Pro Asn		
325	330	335
Pro Leu Gln Lys Trp Glu Asp Ser Ala His Lys Pro Gln Ser Leu Asp		
340	345	350
Thr Asp Asp Pro Ala Thr Leu Tyr Ala Val Val Glu Asn Val Pro Pro		
355	360	365
Leu Arg Trp Lys Glu Phe Val Arg Arg Leu Gly Leu Ser Asp His Glu		
370	375	380
Ile Asp Arg Leu Glu Leu Gln Asn Gly Arg Cys Leu Arg Glu Ala Gln		
385	390	395 400
Tyr Ser Met Leu Ala Thr Trp Arg Arg Arg Thr Pro Arg Arg Glu Ala		
405	410	415
Thr Leu Glu Leu Leu Gly Arg Val Leu Arg Asp Met Asp Leu Leu Gly		
420	425	430
Cys Leu Glu Asp Ile Glu Glu Ala Leu Cys Gly Pro Ala Ala Leu Pro		
435	440	445
Pro Ala Pro Ser Leu Leu Arg		
450	455	

## (2) INFORMATION FOR SEQ ID NO:6:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 365 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: DNA (genomic)

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

TCGGCTGTGT ACCCATTTGA GAAAGCAGCA ACCTCCCTCT CACTGGCATT GCAAAGAAAC	60
TGATAGATAT CTTTCCACTG GCTTCCCACT TGGGCTGCTA CAAGCTTCAG GATATCGATA	120
CCATGGCCAT TGCAGTAGTA GATCCATTTT CCCGGTTCTG GGTGGAGTC ATGGATTTTT	180
CAGCCCTGCC TTTTCCACAA TGGCACTGGG ATCCTGCCGG GGCCCTTTT TAGAGTCCTC	240
GAGCTTTTCC GGATACTGCA CACCACAATC ACCACAAGCA CCAGCAGCAG GAAAAGCACA	300

ATCATCCAGG GCAAATGCTC ATTGATGTCA AAATGCTTGT GTAGGTTCTG TCTAGGATGT 360  
CCCCCT 365

(2) INFORMATION FOR SEQ ID NO:7:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 378 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

AGAAACGATG TTGTGGAGAA GATTCGTGGG CTGATGGAAG ACACCACCCA GCTGGAACT 60  
GACAAACTAG CTCTCCCGAT GAGCCCCAGC CCGCTTAGCC CGAGCCCCAT CCCCAGCCCC 120  
AACGCGAAAC TTGAGAATTC CGCTCTCCTG ACGGTGGAGC CTTCCCCACA GGACAAGAAC 180  
AAGGGCTTCT TCGTGGATGA GTCGGAGCCC CTTCTCCGCT GTACTCTACA TCCAGCGGCT 240  
CCTCCGCGCT GAGCAGGAAC GGTTCCTTTA TTACCAAAGA AAAGAAGGAC ACAGTGTTC 300  
GGCAGGTACG CCTGGACCCC TGTAATTTG CAGCCTATCT TTGATTGACA TGTTCACCTT 360  
TCTAAATCCT GAGGAGTT 378

(2) INFORMATION FOR SEQ ID NO:8:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 345 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:

GGCAGAGGCA CAAGGTAATT TCTCAATCAT TGGCCATGGG CATGGCTGAC TACAGTCATG 60  
GCATTTCTCT ATGCCATTCT CATGCCTGGT AAAGGTCCCC ACAGGGCAAC TGCTGACAGA 120  
CGCGCGGCTT GTGTTGGTAC ATGCTCAGAG ACATAGGTTT CTGCTGGACA CTTGTCACAG 180  
GTTAGCACCT AGCCGGTGGC ACGGTCAACA TGGCGGTATG TGCCAATGAG ATTCGAGGCC 240  
TTCTGTTCTG GCTGAGCTGT GGTGGTGCTA AGGAATCCAA GCGGAGAAGG GAGCCCAGAT 300  
CATCGTGGCT GTGGCTGGCG GCGATGCGG TTCAGGAGGC CGAGG 345

## (2) INFORMATION FOR SEQ ID NO:9:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 316 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: DNA (genomic)

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:

```

GCTAATTAGC GCCCTGCCAG ACCGGAGAAA CGATGTTTGG AGAAGATTCTG TGGGCTGATG      60
GAAGACACCA CCCAGCTGGA AACTGACAAA CTAGCTCTCC CGATGAGCCC CAGCCCGCTT      120
AGCCCGAGCC CCATCCCCAG CCCCAACGCG AAACCTGAGA ATTCCGCTCT CCTGACGGTG      180
GAGCCTTTCC CACAGGACAA GAACAAGGGC TTCTTCGTGG ATGAGTCGGA GCCCCTTCTC      240
CGCTGTACTC TACATCCAGC GGCTCCTCCG GCTGAGCAGG AACGGTTCCT TTATTACCAA      300
GAAAAGAAGG ACACAG                                     316

```

## (2) INFORMATION FOR SEQ ID NO:10:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 489 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: DNA (genomic)

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

```

AATTCGGCAC GAGGAATCCT ATAAGCAGTC TTTATGTCTC TTAACATTCA CACCTACTTT      60
TTAAAAACAA ATATTATTAC TATTTTATT ATTGTTTGTC CTTTATAAAT TTTCTTAAAG      120
ATTAAGAAAA TTAAAGACCC CATTGAGTTA CTGTAATGCA ATTCAACTTT GAGTTATCTT      180
TTAAATATGT CTTGTATAGT TCATATTCAT GGCTGAAACT TGACCACACT ATTGCTGATT      240
GTATGGTTCA CCTGGCACCG TGTAGATGCT TGATTACTTG TACTCTCTTA TGTAATGCT      300
CTGGGCTGGG GAATGAATCC CAGGCTCAGG TTTCCCTATT AAGGGGTTCA CTGGCCCCAA      360
GACTGACTCC CTTGGGGTTG GGTTTGGACA ATGTCTTGGG AGAAAAGCCG GGGCTTCCAG      420
GGTTCCTCTT GTAAGGGTTT TAAAAAAAAG CCATTCTGAG CTCGCCGGGG TCCCATTTAA      480
AAGGGCCCG                                     489

```



## (2) INFORMATION FOR SEQ ID NO:11:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 26 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: DNA (genomic)

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

CGCCCATGGC TCAGCCAGAA CAGAAG

26

## (2) INFORMATION FOR SEQ ID NO:12:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 28 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: DNA (genomic)

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:

CGCAAGCTTT TAGGGCAAAT GTCATG

28

## (2) INFORMATION FOR SEQ ID NO:13:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 33 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: DNA (genomic)

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:13:

CGCCCCGGGG CCATCATGGG GACCTCTCCG AGC

33

## (2) INFORMATION FOR SEQ ID NO:14:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 28 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:14:

CGCGGTACCT TAGGGCAAAT GCTCATTG

28

(2) INFORMATION FOR SEQ ID NO:15:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 55 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15:

CGCTCTAGAT CAAGCGTAGT CTGGGACGTC GTATGGGTAG GGCAAATGCT CATTG

55

(2) INFORMATION FOR SEQ ID NO:16:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 31 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:16:

GGAAGATCTG CCAGAACAGA AGGCCTCGAA T

31

(2) INFORMATION FOR SEQ ID NO:17:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 31 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:17:

CCATCTTCCT GACCTGCTGT AGTCTAGAGC C

31

(2) INFORMATION FOR SEQ ID NO:18:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 30 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:18:

GCCGACCACG AGCGGGCCTA GTCTAGAGCC

30

(2) INFORMATION FOR SEQ ID NO:19:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 147 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:19:

Thr	Cys	Asp	Lys	Cys	Pro	Ala	Gly	Thr	Tyr	Val	Ser	Glu	His	Cys	Thr	1	5	10	15
Asn	Thr	Ser	Leu	Arg	Val	Cys	Ser	Ser	Cys	Pro	Val	Gly	Thr	Phe	Thr	20	25	30	
Arg	His	Glu	Asn	Gly	Ile	Glu	Lys	Cys	His	Asp	Cys	Ser	Gln	Pro	Cys	35	40	45	
Pro	Trp	Pro	Met	Ile	Glu	Lys	Leu	Pro	Cys	Ala	Ala	Leu	Thr	Asp	Arg	50	55	60	
Glu	Cys	Thr	Cys	Pro	Pro	Gly	Met	Phe	Gln	Ser	Asn	Ala	Thr	Cys	Ala	65	70	75	80
Pro	His	Thr	Val	Cys	Pro	Val	Gly	Trp	Gly	Val	Arg	Lys	Lys	Gly	Thr	85	90	95	
Glu	Thr	Glu	Asp	Val	Arg	Cys	Lys	Gln	Cys	Ala	Arg	Gly	Thr	Phe	Ser	100	105	110	
Asp	Val	Pro	Ser	Ser	Val	Met	Pro	Cys	Lys	Ala	Tyr	Thr	Asp	Cys	Leu	115	120	125	
Ser	Gln	Asn	Leu	Val	Val	Ile	Lys	Pro	Gly	Thr	Lys	Glu	Thr	Asp	Asn	130	135	140	
Val	Cys	Gly														145			

## (2) INFORMATION FOR SEQ ID NO:20:

- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 147 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:20:

```

Leu Cys Asp Lys Cys Pro Pro Gly Thr Tyr Leu Lys Gln His Cys Thr
1           5           10           15

Ala Lys Trp Lys Thr Val Cys Ala Pro Cys Pro Asp His Tyr Tyr Thr
20           25           30

Asp Ser Trp His Thr Ser Asp Glu Cys Leu Tyr Cys Ser Pro Val Cys
35           40           45

Lys Glu Leu Gln Tyr Val Lys Gln Glu Cys Asn Arg Thr His Asn Arg
50           55           60

Val Cys Glu Cys Lys Glu Gly Arg Tyr Leu Glu Ile Glu Phe Cys Leu
65           70           75           80

Lys His Arg Ser Cys Pro Pro Gly Phe Gly Val Val Gln Ala Gly Thr
85           90           95

Pro Glu Arg Asn Thr Val Cys Lys Arg Cys Pro Asp Gly Phe Phe Ser
100          105          110

Asn Glu Thr Ser Ser Lys Ala Pro Cys Arg Lys His Thr Asn Cys Ser
115          120          125

Val Phe Gly Leu Leu Leu Thr Gln Lys Gly Asn Ala Thr His Asp Asn
130          135          140

Ile Cys Ser
145

```

## (2) INFORMATION FOR SEQ ID NO:21:

- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 67 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:21:

Gln Trp Lys Asp Ile Tyr Gln Phe Leu Cys Asn Ala Ser Glu Arg Glu  
1 5 10 15

Val Ala Ala Phe Ser Asn Gly Tyr Thr Ala Asp His Glu Arg Ala Tyr  
20 25 30

Ala Ala Leu Gln His Trp Thr Ile Arg Gly Pro Glu Ala Ser Leu Ala  
35 40 45

Gln Leu Ile Ser Ala Leu Arg Gln His Arg Arg Asn Asp Val Val Glu  
50 55 60

Lys Ile Arg  
65

(2) INFORMATION FOR SEQ ID NO:22:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 68 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:22:

Gln Val Lys Gly Phe Val Arg Lys Asn Gly Val Asn Glu Ala Lys Ile  
1 5 10 15

Asp Glu Ile Lys Asn Asp Asn Val Gln Asp Thr Ala Glu Gln Lys Val  
20 25 30

Gln Leu Leu Arg Asn Trp His Gln Leu His Gly Lys Lys Glu Ala Tyr  
35 40 45

Asp Thr Leu Ile Lys Asp Leu Lys Lys Ala Asn Leu Cys Thr Leu Ala  
50 55 60

Glu Lys Ile Gln  
65

(2) INFORMATION FOR SEQ ID NO:23:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 68 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:23:

Arg Trp Lys Glu Phe Val Arg Arg Leu Gly Leu Ser Asp His Glu Ile  
 1                      5                      10                      15  
 Asp Arg Leu Glu Leu Gln Asn Gly Arg Cys Leu Arg Glu Ala Gln Tyr  
                     20                      25                      30  
 Ser Met Leu Ala Thr Trp Arg Arg Arg Thr Arg Arg Glu Ala Thr Leu  
                     35                      40                      45  
 Glu Leu Leu Gly Arg Val Leu Arg Asp Met Asp Leu Leu Gly Cys Leu  
                     50                      55                      60  
 Glu Asp Ile Glu  
 65

## (2) INFORMATION FOR SEQ ID NO:24:

- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 65 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:24:

Arg Trp Lys Glu Phe Val Arg Thr Leu Gly Leu Arg Glu Ala Glu Ile  
 1                      5                      10                      15  
 Glu Ala Val Glu Val Glu Ile Gly Arg Phe Arg Asp Gln Gln Tyr Glu  
                     20                      25                      30  
 Met Leu Lys Arg Trp Arg Gln Gln Gln Pro Ala Gly Leu Gly Ala Val  
                     35                      40                      45  
 Tyr Ala Ala Leu Glu Arg Met Gly Leu Asp Gly Cys Val Glu Asp Leu  
                     50                      55                      60  
 Arg  
 65

## (2) INFORMATION FOR SEQ ID NO:25:

- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 67 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:25:

```

Ser Trp Asp Gln Leu Met Arg Gln Leu Asp Leu Thr Lys Asn Glu Ile
1           5           10           15
Asp Val Val Arg Ala Gly Thr Ala Gly Pro Gly Asp Ala Leu Tyr Ala
20           25           30
Met Leu Met Lys Trp Val Asn Lys Thr Gly Arg Asn Ala Ser Ile His
35           40           45
Thr Leu Leu Asp Ala Leu Glu Arg Met Glu Glu Arg His Ala Lys Glu
50           55           60
Lys Ile Gln
65

```

## (2) INFORMATION FOR SEQ ID NO:26:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 67 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: protein

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:26:

```

Ser Trp Glu Pro Leu Met Arg Lys Leu Gly Leu Met Asp Asn Glu Ile
1           5           10           15
Lys Val Ala Lys Ala Glu Ala Ala Gly His Arg Asp Thr Leu Tyr Thr
20           25           30
Met Leu Ile Lys Trp Val Asn Lys Thr Gly Arg Asp Ala Ser Val His
35           40           45
Thr Leu Leu Asp Ala Leu Glu Thr Leu Gly Glu Arg Leu Ala Lys Gln
50           55           60
Lys Ile Glu
65

```

## INDICATIONS RELATING TO A DEPOSITED MICROORGANISM

(PCT Rule 13bis)

<b>A.</b> The indications made below relate to the microorganism referred to in the description on page <u>4</u> , line <u>12</u>	
<b>B. IDENTIFICATION OF DEPOSIT</b> Further deposits are identified on an additional sheet <input type="checkbox"/>	
Name of depositary institution <div style="text-align: center;">American Type Culture Collection</div>	
Address of depositary institution (including postal code and country) 10801 University Boulevard Manassas, Virginia 20110-2209 United States of America	
Date of deposit    May 15, 1997	Accession Number    209037
<b>C. ADDITIONAL INDICATIONS</b> (leave blank if not applicable) This information is continued on an additional sheet <input type="checkbox"/>	
<b>D. DESIGNATED STATES FOR WHICH INDICATIONS ARE MADE</b> (if the indications are not for all designated States)	
<b>E. SEPARATE FURNISHING OF INDICATIONS</b> (leave blank if not applicable)	
The indications listed below will be submitted to the International Bureau later (specify the general nature of the indications, e.g., "Accession Number of Deposit")	

<div style="border-bottom: 1px solid black; margin-bottom: 5px;">For receiving Office use only</div> <div style="display: flex; align-items: center; margin-bottom: 10px;"><input checked="checked" type="checkbox"/> This sheet was received with the international application</div> <div style="display: flex; align-items: center;"><div style="flex: 1;">Authorized officer</div><div style="text-align: center; flex: 2;"> Kate Simon Paralegal Specialist IAPD-PCT Operations (703) 305-3746</div></div>	<div style="border-bottom: 1px solid black; margin-bottom: 5px;">For International Bureau use only</div> <div style="display: flex; align-items: center; margin-bottom: 10px;"><input type="checkbox"/> This sheet was received by the International Bureau on:</div> <div style="display: flex; align-items: center;"><div style="flex: 1;">Authorized officer</div><div style="flex: 2;"></div></div>
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*What Is Claimed Is:*

1. An isolated nucleic acid molecule comprising a polynucleotide having a nucleotide sequence at least 95% identical to a sequence selected from the group consisting of:

(a) a nucleotide sequence encoding a polypeptide comprising amino acids from about -40 to about 615 in SEQ ID NO:2;

(b) a nucleotide sequence encoding a polypeptide comprising amino acids from about -39 to about 615 in SEQ ID NO:2;

(c) a nucleotide sequence encoding a polypeptide comprising amino acids from about 1 to about 615 in SEQ ID NO:2;

(d) a nucleotide sequence encoding a polypeptide having the amino acid sequence encoded by the cDNA clone contained in ATCC Deposit No. 209037;

(e) a nucleotide sequence encoding the mature TR9 polypeptide having the amino acid sequence encoded by the cDNA clone contained in ATCC Deposit No. 209037;

(f) a nucleotide sequence encoding the TR9 extracellular domain;

(g) a nucleotide sequence encoding the TR9 transmembrane domain;

(h) a nucleotide sequence encoding the TR9 intracellular domain;

(i) a nucleotide sequence encoding the TR9 receptor extracellular and intracellular domains with all or part of the transmembrane domain deleted;

(j) a nucleotide sequence encoding the TR9 death domain;  
and

(k) a nucleotide sequence complementary to any of the nucleotide sequences in (a), (b), (c), (d), (e), (f), (g), (h), (i), or (j).

2. The nucleic acid molecule of claim 1 wherein said polynucleotide has the nucleotide sequence in SEQ ID NO:1.

3. The nucleic acid molecule of claim 1 wherein said polynucleotide has the nucleotide sequence in SEQ ID NO:1 encoding the TR9 receptor having the amino acid sequence in SEQ ID NO:2.

4. The nucleic acid molecule of claim 1 wherein said polynucleotide has the nucleotide sequence in SEQ ID NO:1 encoding the mature TR9 receptor having the amino acid sequence in SEQ ID NO:2.

5. The nucleic acid molecule of claim 1 wherein said polynucleotide has the nucleotide sequence of the cDNA clone contained in ATCC Deposit No. 209037.

6. The nucleic acid molecule of claim 1 wherein said polynucleotide has the nucleotide sequence encoding the TR9 receptor having the amino acid sequence encoded by the cDNA clone contained in ATCC Deposit No. 209037.

7. The nucleic acid molecule of claim 1 wherein said polynucleotide has the nucleotide sequence encoding the mature TR9 receptor having the amino acid sequence encoded by the cDNA clone contained in ATCC Deposit No. 209037.

8. An isolated nucleic acid molecule comprising a polynucleotide which hybridizes under stringent hybridization conditions to a polynucleotide having

a nucleotide sequence identical to a nucleotide sequence in (a), (b), (c), (d), (e), (f), (g), (h), (i), (j), or (k) of claim 1 wherein said polynucleotide which hybridizes does not hybridize under stringent hybridization conditions to a polynucleotide having a nucleotide sequence consisting of only A residues or of only T residues.

9. An isolated nucleic acid molecule comprising a polynucleotide which encodes the amino acid sequence of an epitope-bearing portion of a TR9 receptor having an amino acid sequence in (a), (b), (c), (d), (e), (f), (g), (h), (i), or (j) of claim 1.

10. The isolated nucleic acid molecule of claim 9, which encodes an epitope-bearing portion of a TR9 receptor selected from the group consisting of: a polypeptide comprising amino acid residues from about 4 to about 81 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 116 to about 271 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 283 to about 308 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 336 to about 372 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 393 to about 434 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 445 to about 559 in SEQ ID NO:2; and a polypeptide comprising amino acid residues from about 571 to about 588 in SEQ ID NO:2.

11. The isolated nucleic acid molecule of claim 1, which encodes the TR9 receptor extracellular domain.

12. The isolated nucleic acid molecule of claim 1, which encodes the TR9 receptor transmembrane domain.

13. The isolated nucleic acid molecule of claim 1, which encodes the TR9 receptor intracellular domain.

14. An isolated nucleic acid molecule comprising a polynucleotide having a sequence at least 95% identical to a sequence selected from the group consisting of:

(a) the nucleotide sequence of clone HIBEJ86R (SEQ ID NO:6);

(b) the nucleotide sequence of clone HL1AA79R (SEQ ID NO:7);

(c) the nucleotide sequence of clone HHFGD57R (SEQ ID NO:8);

(d) the nucleotide sequence of clone HSABG38R (SEQ ID NO:9);

(e) the nucleotide sequence of clone HHPDZ31R (SEQ ID NO:10);

(f) the nucleotide sequence of a portion of the sequence shown in SEQ ID NO:1 wherein said portion comprises at least 50 contiguous nucleotides from nucleotide 500 to nucleotide 980; and

(g) a nucleotide sequence complementary to any of the nucleotide sequences in (a), (b), (c), (d), (e), or (f) above.

15. A method for making a recombinant vector comprising inserting an isolated nucleic acid molecule of claim 1 into a vector.

16. A recombinant vector produced by the method of claim 15.

17. A method of making a recombinant host cell comprising introducing the recombinant vector of claim 16 into a host cell.

18. A recombinant host cell produced by the method of claim 17.
19. A recombinant method for producing a TR9 polypeptide, comprising culturing the recombinant host cell of claim 18 under conditions such that said polypeptide is expressed and recovering said polypeptide.
20. An isolated TR9 polypeptide having an amino acid sequence at least 95% identical to a sequence selected from the group consisting of:
- (a) amino acids from about -40 to about 615 in SEQ ID NO:2;
  - (b) amino acids from about -39 to about 615 in SEQ ID NO:2;
  - (c) amino acids from about 1 to about 615 in SEQ ID NO:2;
  - (d) the amino acid sequence of the TR9 polypeptide having the amino acid sequence encoded by the cDNA clone contained in ATCC Deposit No. 209037;
  - (e) the amino acid sequence of the mature TR9 polypeptide having the amino acid sequence encoded by the cDNA clone contained in ATCC Deposit No. 209037;
  - (f) the amino acid sequence of the TR9 receptor extracellular domain;
  - (g) the amino acid sequence of the TR9 receptor transmembrane domain;
  - (h) the amino acid sequence of the TR9 receptor intracellular domain;
  - (i) the amino acid sequence of the TR9 receptor intracellular and extracellular domains with all or part of the transmembrane domain deleted;
  - (j) the amino acid sequence of the TR9 receptor death domain; and

(k) the amino acid sequence of an epitope-bearing portion of any one of the polypeptides of (a), (b), (c), (d), (e), (f), (g), (h), (i), or (j).

21. An isolated polypeptide comprising an epitope-bearing portion of the TR9 receptor protein, wherein said portion is selected from the group consisting of: a polypeptide comprising amino acid residues from about 4 to about 81 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 116 to about 271 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 283 to about 308 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 336 to about 372 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 393 to about 434 in SEQ ID NO:2; a polypeptide comprising amino acid residues from about 445 to about 559 in SEQ ID NO:2; and a polypeptide comprising amino acid residues from about 571 to about 588 in SEQ ID NO:2.

22. An isolated antibody that binds specifically to a TR9 receptor polypeptide of claim 20.

23. An isolated nucleic acid molecule comprising a polynucleotide encoding a TR9 receptor polypeptide wherein, except for at least one conservative amino acid substitution, said polypeptide has a sequence selected from the group consisting of:

(a) a nucleotide sequence encoding a polypeptide comprising amino acids from about -40 to about 615 in SEQ ID NO:2;

(b) a nucleotide sequence encoding a polypeptide comprising amino acids from about -39 to about 615 in SEQ ID NO:2;

(c) a nucleotide sequence encoding a polypeptide comprising amino acids from about 1 to about 615 in SEQ ID NO:2;

(d) a nucleotide sequence encoding a polypeptide having the amino acid sequence encoded by the cDNA clone contained in ATCC Deposit No.

209037;

(e) a nucleotide sequence encoding the mature TR9 polypeptide having the amino acid sequence encoded by the cDNA clone contained in ATCC Deposit No. 209037;

(f) a nucleotide sequence encoding the TR9 extracellular domain;

(g) a nucleotide sequence encoding the TR9 transmembrane domain;

(h) a nucleotide sequence encoding the TR9 intracellular domain;

(i) a nucleotide sequence encoding the TR9 receptor extracellular and intracellular domains with all or part of the transmembrane domain deleted;

(j) a nucleotide sequence encoding the TR9 death domain;  
and

(k) a nucleotide sequence complementary to any of the nucleotide sequences in (a), (b), (c), (d), (e), (f), (g), (h), (i), or (j).

24. An isolated TR9 receptor polypeptide wherein, except for at least one conservative amino acid substitution, said polypeptide has a sequence selected from the group consisting of:

(a) amino acids from about -40 to about 615 in SEQ ID NO:2;

(b) amino acids from about -39 to about 615 in SEQ ID NO:2;

(c) amino acids from about 1 to about 615 in SEQ ID NO:2;

(d) the amino acid sequence of the TR9 polypeptide having the amino acid sequence encoded by the cDNA clone contained in ATCC Deposit No. 209037;

(e) the amino acid sequence of the mature TR9 polypeptide having the amino acid sequence encoded by the cDNA clone contained in ATCC Deposit No. 209037;

(f) the amino acid sequence of the TR9 receptor extracellular domain;

(g) the amino acid sequence of the TR9 receptor transmembrane domain;

(h) the amino acid sequence of the TR9 receptor intracellular domain;

(i) the amino acid sequence of the TR9 receptor extracellular and intracellular domains with all or part of the transmembrane domain deleted;

(j) the amino acid sequence of the TR9 receptor death domain; and

(k) the amino acid sequence of an epitope-bearing portion of any one of the polypeptides of (a), (b), (c), (d), (e), (f), (g), (h), (i), or (j).



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10 30 50  
GCGGGCTGCAGTCGCGGGGCTTCTCCCGCCTGGGCGGCCGCGCCGCTGGGCAGGTGCT  
70 90 110  
GAGCGCCCCTAGAGCCTCCCTTGCCGCCTCCCTCCTCTGCCCCGCCGAGCAGTGCACAT  
130 150 170  
GGGGTGTGGAGGTAGATGGGCTCCCGGCCCGGAGGCGGCGGTGGATGCGGCGCTGGGC  
190 210 230  
AGAAGCAGCCGCCGATTCCAGCTGCCCCGCGCGCCCCGGGCGCCCTGCGAGTCCCCGGT  
250 270 290  
TCAGCCATGGGGACCTCTCCGAGCAGCAGCACCGCCCTCGCCTCCTGCAGCCGCATCGCC  
M G T S P S S S T A L A S C S R I A  
310 330 350  
CGCCGAGCCACAGCCACGATGATCGCGGGCTCCCTTCTCCTGCTTGGATTCCCTTAGCACC  
R R A T A T M I A G S L L L L G F L S T  
370 390 410  
ACCACAGCTCAGCCAGAACAGAAGGCTCGAATCTCATTGGCACATACCGCCATGTTGAC  
T T A Q P E Q K A S N L I G T Y R H V D  
430 450 470  
CGTGCCACCGCCAGGTGCTAACCTGTGACAAGTGTCCAGCAGGAACCTATGTCTCTGAG  
R A T G Q V L T C D K C P A G T Y V S E  
490 510 530  
CATTGTACCAACACAAGCCTGCGGCTGCGAGCAGTTGCCCTGTGGGGACCTTTACCAGG  
H C T N T S L R V C S S C P V G T F T R  
550 570 590  
CATGAGAATGGCATAGAGAAATGCCATGACTGTAGTCAGCCATGCCCATGGCCAATGATT  
H E N G I E K C H D C S Q P C P W P M I  
610 630 650  
GAGAAATTACCTTGTGCTGCCTTGACTGACCGAGAATGCACTTGCCACCTGGCATGTTG  
E K L P C A A L T D R E C T C P P G M F  
670 690 710  
CAGTCTAACGCTACCTGTGCCCCCATACGGTGTGTCTGTGGGTGCGGTGTGCGGAAG  
Q S N A T C A P H T V C P V G W G V R K  
730 750 770  
AAAGGGACAGAGACTGAGGATGTGCGGTGTAAGCAGTGTGCTCGGGGTACCTTCTCAGAT  
K G T E T E D V R C K Q C A R G T F S D  
790 810 830  
GTGCCTTCTAGTGTGATGAAATGCAAAGCATACACAGACTGTCTGAGTCAGAACCTGGTG  
V P S S V M K C K A Y T D C L S Q N L V  
850 870 890  
GTGATCAAGCGGGGACCAAGGAGACAGACAACGTCTGTGGCACACTCCCGTCCTTCTCC  
V I K P G T K E T D N V C G T L P S F S  
910 930 950

FIG. 1A

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AGCTCCACCTCACCTTCCCCTGGCACAGCCATCTTCCACGCCCTGAGCACATGGAAACC  
S S T S P S P G T A I F P R P E H M E T  
970 990 1010  
CATGAAGTCCCTTCCCTCACTTATGTTCCCAAAGGCATGAACCAAGAATCCAACCT  
H E V P S S T Y V P K G M N S T E S N S  
1030 1050 1070  
TCTGCCTCTGTTAGACCAAAGGTACTGAGTAGCATCCAGGAAGGGACAGTCCCTGACAAC  
S A S V R P K V L S S I Q E G T V P D N  
1090 1110 1130  
ACAAGCTCAGCAAGGGGAAGGAAGACGTGAACAAGACCCTCCCAAACCTTCAGGTAGTC  
T S S A R G K E D V N K T L P N L Q V V  
1150 1170 1190  
AACCACCAGCAAGGCCCCCACCACAGACACATCCTGAAGCTGCTGCCGTCCATGGAGGCC  
N H Q Q G P H H R H I L K L L P S M E A  
1210 1230 1250  
ACTGGGGCGGAGAAGTCCAGCACGCCCATCAAGGGCCCCAAGAGGGGACATCCTAGACAG  
T G G E K S S T P I K G P K R G H P R Q  
1270 1290 1310  
AACCTACACAAGCATTTTGACATCAATGAGCATTTGCCCTGGATGATTGTGCTTTTCCTG  
N L H K H F D I N E H L P W M I V L F L  
1330 1350 1370  
CTGCTGGTGCTTGTGGTGATTGTGGTGTCAGTATCCGAAAAGCTCGAGGACTCTGAAA  
L L V L V V I V V C S I R K S S R T L K  
1390 1410 1430  
AAGGGGCCCCGGCAGGATCCCAGTGCCATTGTGGAAAAGGCAGGGCTGAAGAAATCCATG  
K G P R Q D P S A I V E K A G L K K S M  
1450 1470 1490  
ACTCCAACCCAGAACCAGGAGAAATGGATCTACTACTGCAATGGCCATGGTATCGATATC  
T P T Q N R E K W I Y Y C N G H G I D I  
1510 1530 1550  
CTGAAGCTTGTAGCAGCCAAGTGGGAAGCCAGTGGAAAGATATCTATCAGTTTCTTTGC  
L K L V A A Q V G S Q W K D I Y Q F L C  
1570 1590 1610  
AATGCCAGTGAGAGGGAGGTGCTGCTTTCTCCAATGGGTACACAGCCGACCACGAGCGG  
N A S E R E V A A F S N G Y T A D H E R  
1630 1650 1670  
GCCTACGCAGCTCTGCAGCACTGGACCATCCGGGGCCCCGAGGCCAGCCTCGCCCAGCTA  
A Y A A L Q H W T I R G P E A S L A Q L  
1690 1710 1730  
ATTAGCGCCCTGCGCCAGCACCGGAGAAACGATGTTGTGGAGAAGATTGCTGGGCTGATG  
I S A L R Q H R R N D V V E K I R G L M  
1750 1770 1790

FIG. 1B

SUBSTITUTE SHEET (RULE 26)

[illegible]

**SUBSTITUTE SHEET (RULE 26)**

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TTTAAAAACAAATATTATTACTATTTTTATTATTGTTTGCCTTTATAAATTTCTTAAA  
2770 2790 2810  
GATTAAGAAAATTTAAGACCCCATTGAGTTACTGTAATGCAATTCAACTTTGAGTTATCT  
2830 2850 2870  
TTTAAATATGCTTGTATAGTTCATATTTCATGGCTGAAACTTGACCACACTATTGCTGAT  
2890 2910 2930  
TGTATGGTTTTTACCTGGACACCGTGTAGAATGCTTGATTACTTGTACTCTTCTTATGCT  
2950 2970 2990  
AATATGCTCTGGGCTGGAGAAATGAAATCCTCAAGCCATCAGGATTTGCTATTTAAGTGG  
3010 3030 3050  
CTTGACAACCTGGGCCACCAAAGAACTTGAACCTTACCTTTTAGGATTTGAGCTGTTCTGG  
3070 3090 3110  
AACACATTGCTGCACTTTGGAAAGTCAAAATCAAGTGCCAGTGGCGCCCTTTCCATAGAG  
3130 3150 3170  
AATTTGCCAGCTTTGCTTTAAAGATGCTTGTGTTTTTATATACACATAATCAATAGGT  
3190 3210 3230  
CCAATCTGCTCTCAAGGCCTTGGTCCTGGTGGGATTCCTTCACCAATTACTTTAATTAAA  
3250 3270 3290  
AATGGCTGCAACTGTAAGAACCCTTGTCTGATATATTGCAACTATGCTCCCATTTACAA  
3310 3330 3350  
ATGTACCTTCTAATGCTCAGTTGCCAGGTTCCAATGCAAAGGTGGCGTGGACTCCCTTTG  
3370 3390 3410  
TGTGGGTGGGGTTTGTGGGTAGTGGTGAAGGACCGATATCAGAAAAATGCCTTCAAGTGT  
3430 3450 3470  
ACTAATTTATTAATAAACATTAGGTGTTTGTAAAAA

FIG. 1D

CPPGERKARDC TVNGDEPDC VPCQEGKEYTDKAHFSSKCRRCRI - CDEGHGLEVEIN - CIR TQNTKCPCK h Fas  
447 CNLGEGVAPCG - - ANQTVCEPCLD SVTFSDVVSATEPC KPCTE - C - - - VGLQSMSAPC VEA DDAVCECA h NGR p75  
452 CHKGTLYNDCPGPGQDTDCRECESGS - FTASENHRLRHC LSCSK - CRKEMG - QVEI SSCTVDR LTYCGCR h TNFR 1  
460 CPAGT YVSEHCT - NTS LRVCSSC - PVGTFTRHENGIEKCHDCSQPC - - - PWPMIEKLP CAAALT DRECTCP TR9

[illegible]

154 IKEC - T L T S N T - - - - - K C K E E G S R S N I - - - - - h Fas  
157 L R E C T R W A D A E C E E I P C R W I T R S T P P E G S D S T A P S T Q E P E A P P E Q D L I A S T V A G V V T V M G S S Q P V V T R G h N G R P 75  
192 T K L C L P Q I E N V - - - - - K G T E D S G T T V L L F - - - - - h T N F R I  
200 I K P G T K E T D N V C G T L P S F S S S T S P S P G T A I F P R P E H M E T H E V P S S T Y V P K G M N S T E S N S S A S V R P K V L S S T R 9

175    - - - - - G W L C - - - - - L L L P I - - - - - h Fas  
247 T T D N L I P V Y C S I L A A V V G L V A Y I A F K R W N S C K Q N K Q G A N S E P V N Q T P P P E C E K L H S D S G I S V D S - - - - - h NGFR p75  
216    - - - - - I V I F F C L C - - - - - L L S L L F I - - - - - h TNFR 1  
270 I Q E G T V P D N T S S A R G K E D V N K T L P N L Q V - - - V N H Q Q G P H R H I L K L L F S M E A T G G E K S S T P I K G P K R G H T R 9

**FIG. 2A**

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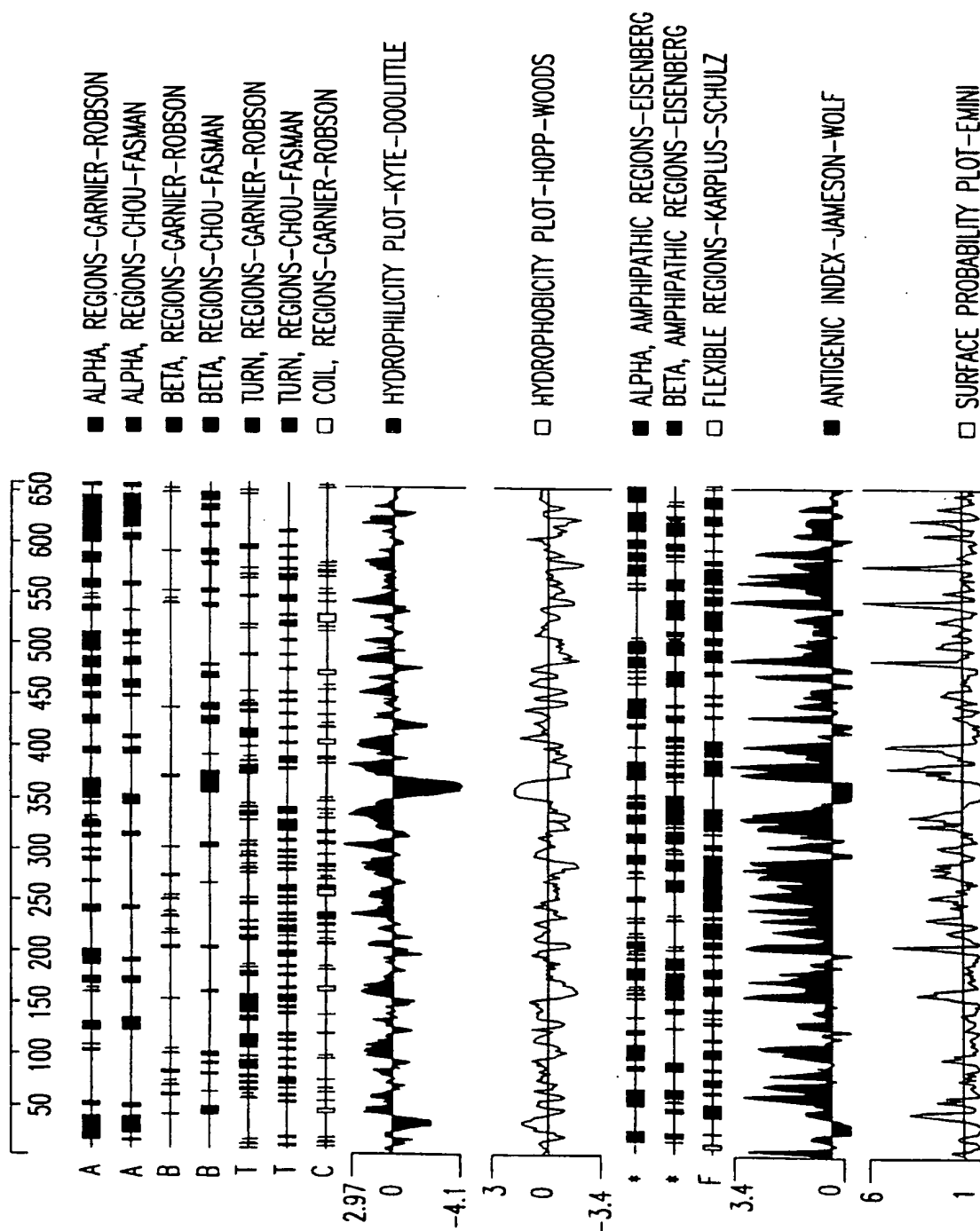


FIG.3

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1 MCTSPSSSTALASCSRIARRATATMIAGSLLLLGFLSTTTAQPEQKASNL IGTYRHVDRAIGQVLTCDKC 70  
 PAGTYVSEHCINTSLRVCS SCPVGTFTRHENGIEKCHDCSQCPWPMIEKLPCAALTDRECTCPPGMFQS 140  
 NATCAAPHTVCPVGWGVRRKKGTEDEVRCCKQCARGTSDVPSSVMKCKAYTDLSONLVV IKPGTKETDNV 210  
 CGTLPFSSTSPSGTAIFRPEHMETHEVPSSTYVPKGMNSTESNSSASVRPKVLS SIQEGTVPDNTS 280  
 SARGKEDVNKTLPNLQVNVHQGPHRHILKLLPSMEATGCEKSSPTIKGPKRGHPRQNLHKHFDINEHL 350  
PWMIVLFLLLVLVVI VVCSIRKSSRTLKKGPRQDPSAIVEKAGLKKSMIPTQNREKWIYYCNGHGIDILK 420  
 LVAAQVGSQWDIYQFLCNASEREVAAF SNGYTTADHERAYAALQHWTIRGPEASLAQLISALRQHRRNDV 490  
VEKIRGLMEDTTQLETDKLALPMSPSPSPSPIPSPNAKLENSALLTVEPSPQDKNKGFFVDESEPLLRC 560  
 DSTSSGSSALSRNGSFITKEKDTVLRQVRLDPCDLQPIFDDMLHFLNPEELRVIEEIPQAEDKLDRLF 630  
 IIGVKSQEASQTLLDSVYSHLPDLL 655

FIG. 4A



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TCDKCPAGTYVSEHCTNTSLRVCS	SCPVGTFTRHENGIEK	TR9(65-105)
LCDKCPPGTYLKQHCTAKWKTVCAP	CPDHYYTDSWHTSDE	OPG(40-80)
CHDCSQPCPWPMTEKLPCAALTDRE	CTCPPGMFQSNATCA	TR9(106-145)
CLYCSPVCKELOQYVKQECNRTHNR	VCECKEGRYLEIEFCL	OPG(81-120)
PHTVCPVGWGVRRKGTETEDVROKQ	CARGTFSDVPSSVMK	TR9(146-185)
KHRSCPPGFGVVQAGTPERNTVCKR	CPDGFFSNETSSKAP	OPG(121-16)
CKAYTDCLSONLVVIKPGTKETDNVCO		TR9(186-212)
CRKHTNCSVFGLLLTQKGNATHDNICS		OPG(161-186)

FIG.4B

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QWKDIYQFLCNASEREVAAFSNGYTAD-HE	TR9	(429-457)
QVKGfVRKN-GVNEAKIDEIKNDNVQDTAE	CD95	(244-272)
RWKEFVRRL-GLSDHEIDRLLELONGRCLRE	TNFR1	(370-398)
RWKEFVRTL-GLREAEIEAVEVEIGR-FRD	DR3	(346-373)
SWDQLMRQL-DLTKNEIDVVRAGTAGP-GD	DR4	(379-406)
SWEPLMRKL-GLNDNEIKVAKAEAAGH-RD	DR5	(324-351)
RAYAALQHWITIR-GPEASLAQLISALRQHR	TR9	(458-486)
QKVQLLRNWHQLHGKKEAYDTLIKDLKKN	CD95	(273-302)
AQYSMLATWRRRTIRREATLELLGRVLRDMD	TNFR1	(399-428)
QQYEMLKRWRQ--QQPAGLGAVYAALERMG	DR3	(374-401)
ALYAMLKWKVNKTGRNASIHTLLDALERME	DR4	(407-436)
TLYTMLIKWKVNKTGRDASVHTLLDALETLG	DR5	(352-381)
RNDVVEKIR	TR9	(487-495)
LCTLAEKIQ	CD95	(303-311)
LLGCLEDIE	TNFR1	(429-437)
LDGCVEDLR	DR3	(402-410)
ERHAKEKIQ	DR4	(437-445)
ERLAKQKIE	DR5	(382-390)

FIG.4C

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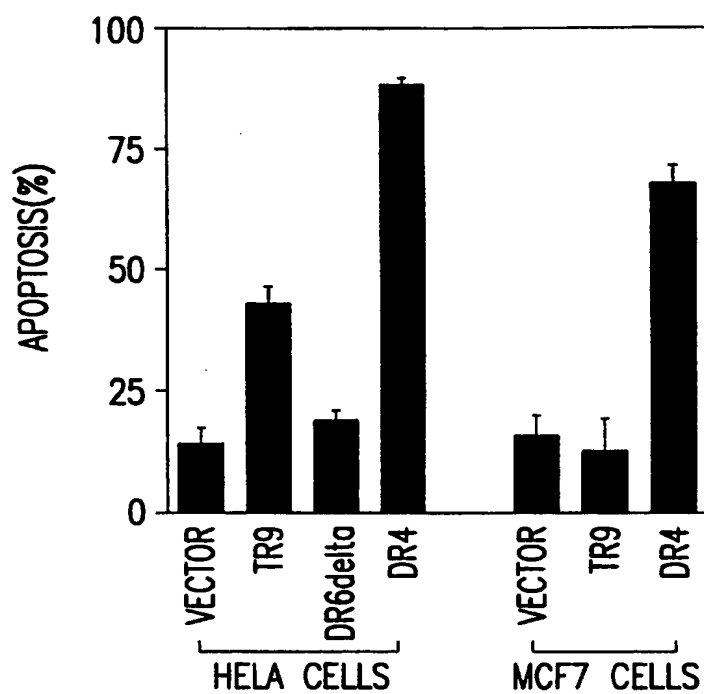


FIG.5

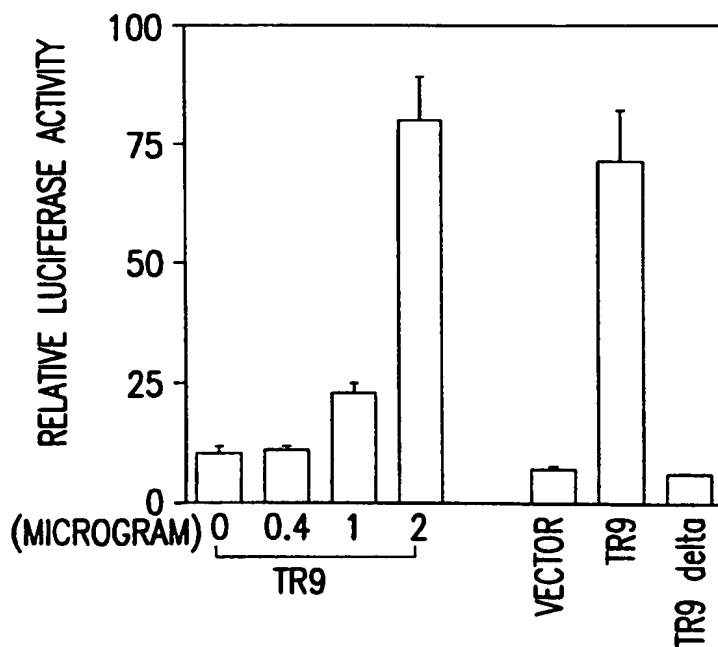


FIG.6

## INTERNATIONAL SEARCH REPORT

 International application No.  
PCT/US98/11932
**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) : Please See Extra Sheet.

US CL : Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 435/69.1, 252.3, 320.1; 530/300, 324, 350, 387.9, 388.22; 536/23.1, 23.5

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
1993/94 New England Biolabs Catalog

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS, EMBL, GENE BANK, PIR, GENESEQ, SWISSPROT  
search terms: TR9, SEQ ID NO:1, 2, 6-10**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	New England Biolabs 1993/94 Catalog. Random Primer, page 91.	8
X, P	Database EST on MPSRCH, Accession Numbers AA555059 (08 September 1997), AA181032 (10 March 1998), AA621819 (31 October 1997), AA554244 (09 September 1997), AA662654 (12 November 1997), AA186423 (10 March 1998).	8
X	Database EST on MPSRCH Accession Numbers AA156356 (11 December 1996), N49208 (14 February 1996), AA351536 (21 April 1997), AA155873 (11 December 1996), D59902 (21 May 1996), H41872 (31 July 1995), AA357231 (21 April 1997), H41873 (31 July 1995)	8



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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*E* earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Z* document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

19 AUGUST 1998

Date of mailing of the international search report

13 OCT 1998

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**INTERNATIONAL SEARCH REPORT**

International application No.  
PCT/US98/11932

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Database EST on MPSRCH, Accession Numbers AA351536 (21 April 1997), AA357231 (21 April 1997), AA374471 (21 April 1997).	14

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US98/11932

## A. CLASSIFICATION OF SUBJECT MATTER:

IPC (6): C12K 21/04, 14/47, 14/705, 16/28; C12N 1/21, 15/11, 15/12, 15/63, 15/64, 15/70, 15/79, 15/85

## A. CLASSIFICATION OF SUBJECT MATTER:

US CL : 435/69.1, 252.3, 320.1; 530/300, 324, 350, 387.9, 388.22; 536/23.1, 23.5